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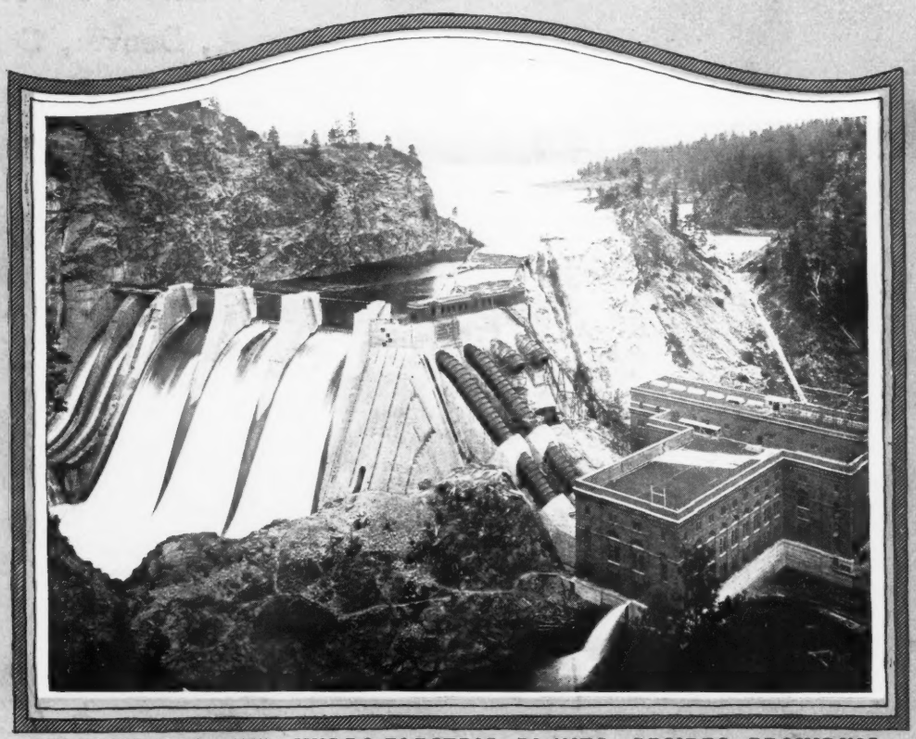

WATERFALLS AND HYDRO-ELECTRIC PLANTS, BESIDES PROVIDING ENERGY FOR MOTIVE PURPOSES, MAY BE UTILIZED TO FIX ATMOSPHERIC NITROGEN. SEE LEADING ARTICLE.

Tapping the Atmosphere for Needful Nitrogen
Robert G. Skerrett

The Air Compressor in the Power Plant
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For Best Results from Hammer Drills
Howard R. Drullard

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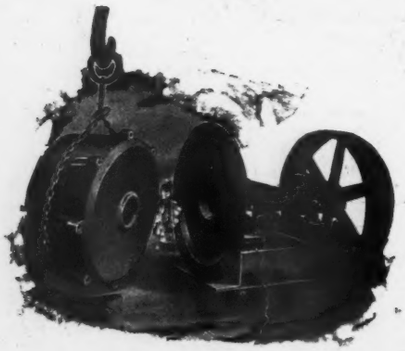

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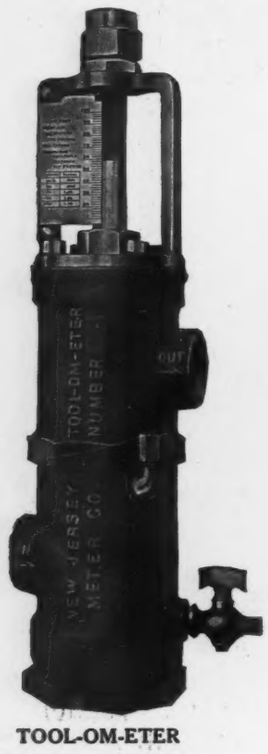

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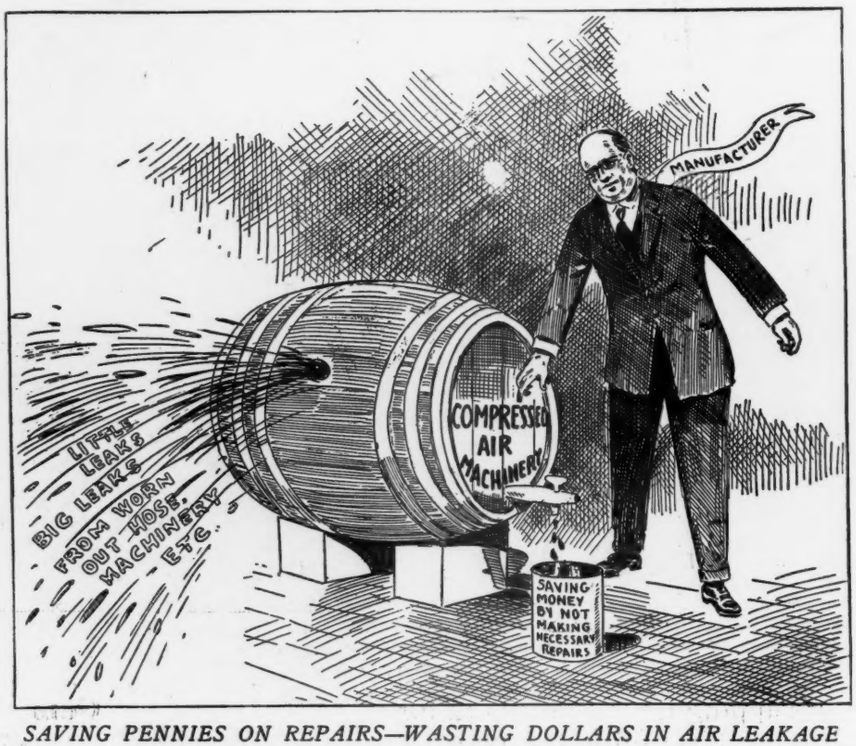
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LITTLE LEAKS BIG LEAKS FROM WORN OUT HOSE, MACHINERY, ETC.
SAVING MONEY BY NOT MAKING NECESSARY REPAIRS

SAVING PENNIES ON REPAIRS—WASTING DOLLARS IN AIR LEAKAGE

The above cartoon reprinted from Compressed Air Magazine; April, 1920, page 9633, shows the plight of any air user who fails to investigate his losses.

Write for Bulletin 5-A

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DECEMBER, 1920

Tapping the Atmosphere for Needful Nitrogen

Fertilization of an Extensive Acreage is Necessary for the Feeding of the Entire World—Large Air Compressor Installations are Used for the Liquefaction of Air

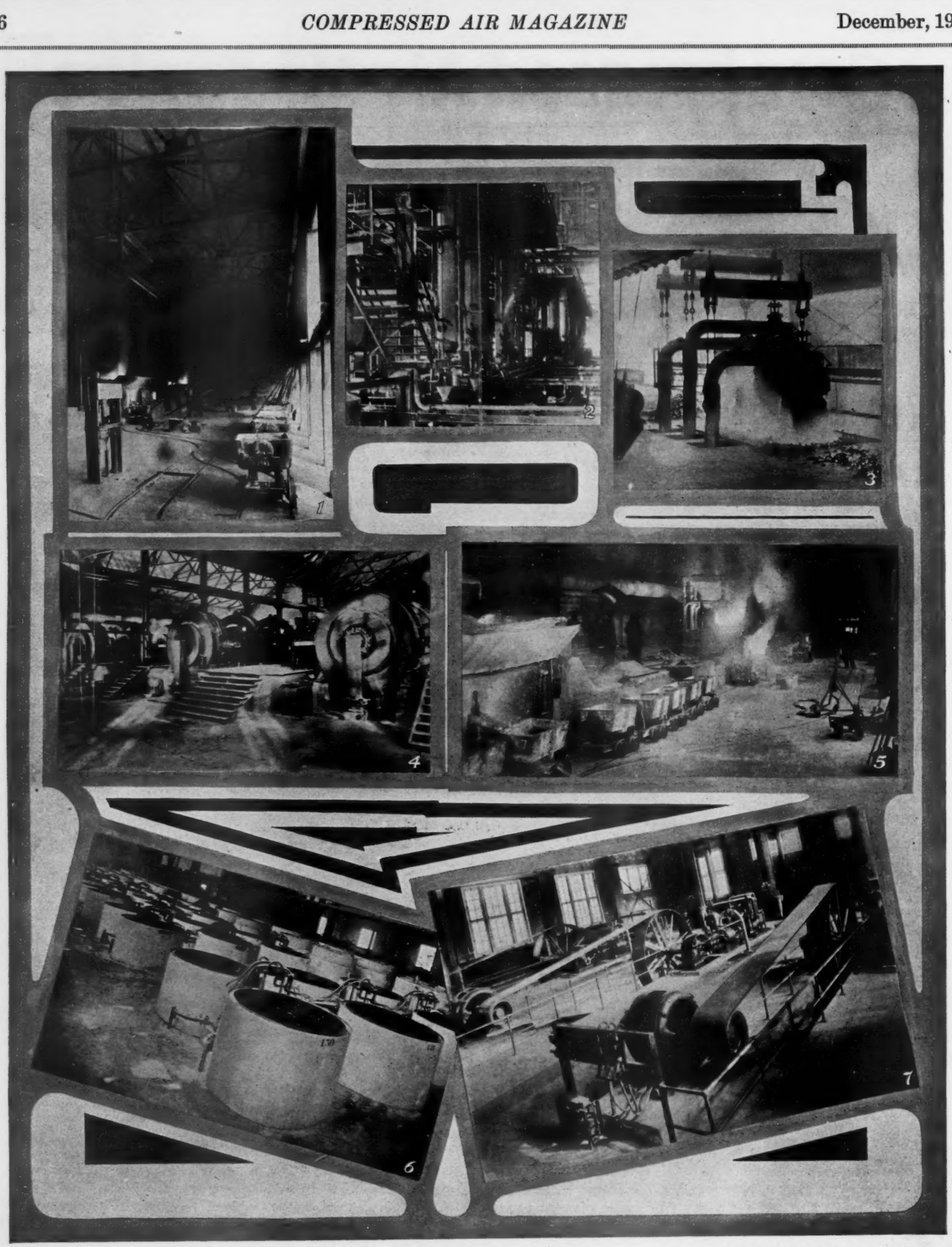
By Robert G. Skerrett

The compressor battery at plant No. 2, Muscle Shoals, Alabama. This is the largest high-pressure air compressing plant in the world, and the liquid air produced is five times greater in volume than that of any other installation of the same character. Nitrogen can be produced at the rate of 500,000 cubic feet per hour.

FREE AIR has come to mean recently a good deal more than the sustaining medium for the breathing creatures of this globe of ours. Science has revealed and practically demonstrated that the atmosphere can be drawn upon to greatly increase the yields of our cultivated fields, to provide substances essential to industrial activities, and to furnish us with a corrosive chemical indispensable to the effective service of both arms of the national defense. In short, the air is rich in a store of nitrogen—a gaseous element vital to our wellbeing in many ways.

To most of us nitrogen is a term that means but little. This is because the majority of us do not realize how important a part it plays in our daily lives. Precious few of us are aware that we have hitherto been spending immense sums annually for years in the purchase of nitrogenous products of foreign origin. The pharmaceutical chemist, the maker of coal-tar dyes, the manufacturer of steel, the producer of munitions, and the farmer are all consumers of nitrogen in one form or another. Indeed, to bring the subject more directly home to every one of us, let it be recalled that we should not have our essential loaf but for the nitrogen carried in the ground and drawn therefrom by our crops of cereals.

In the decades past, the soil's store of nitrogen sufficed to insure productiveness, but as man garnered his grain, season after season, without returning to the ground a proportionate share of this necessary plant food, he crippled the earth's capacity to furnish the desired measure of sustenance. The day came when virgin acres were no longer available, and to revitalize the exhausted fields, means had to be found that would restore from time to time the depleted nitrogen so that more grain could be grown on a given area to sat-



Courtesy American Cyanamid Company.

Fig. 1—The furnace room where coke and lime are fused by electricity and converted into calcium carbide. It is this material, when pulverized, which is treated so that it will absorb and hold gaseous nitrogen. Fig. 2—Concentration towers in a plant for the fixation of atmospheric nitrogen by means of the electric arc. In these towers the nitric acid is progressively concentrated until it reaches the desired degree of strength. Fig. 3— A close-up of an electric furnace at Niagara Falls which turns out calcium carbide as the "carrier for atmospheric nitrogen." Fig. 4—Birkeland-Eyed furnaces within which the intense heat of the electric arc effects a union between the molecules of oxygen and nitrogen and produces nitric oxide. Fig. 5—Another view of the furnace room at Niagara Falls. Here are seen the metal cars lined up to be loaded with calcium carbide. Fig. 6—Electric ovens in which calcium carbide, after being pulverized is exposed to pure nitrogen. The carbide absorbs the nitrogen and this union produces calcium cyanamid, which may be used, first, directly as a fertilizer, second, may yield ammonia, and third, may be depended upon to furnish nitric acid for munitions, etc. Fig. 7—A group of electrically driven air compressors used in the process by which pure nitrogen is obtained from the free atmosphere preliminary to effecting its fixation with calcium carbide.

isfy the hunger of a greater and a denser non-agricultural populace.

Within the memory of most of us, this was largely achieved by using the plant food of the barnyard and then supplementing this with fertilizers from distant sources, such as the guano of Peru and elsewhere, and later the sodium nitrate of Chile. But 22 years ago, an eminent British physicist, Sir William Crookes, sounded a note of warning. He pointed out in a startling fashion that the breadeaters of the world were increasing at the rate of 6,000,000 annually, while the acreage suitable to the growing of cereals was positively limited. As he said, the one solution of the grave problem thus presented lay in making each useful acre produce larger crops, and he emphasized that this would be possible only by intensive cultivation through the more generous use of fertilizers rich, of course, in nitrogen.

In 1898, as Sir William explained, the acreage of cereals aggregated 167,000,000 and but 100,000,000 acres more remained available for the growing of these breadstuffs. Of wheat alone, the annual per capita consumption then was 4.6 bushels, while the average yield was 12.8 bushels per acre. Upon that basis, he estimated that the wheat fields of the world would have to cover 292,000,000 acres by 1941 in order to satisfy a breadeating population which he calculated would have increased to about 820,000,000.

The heedless smiled complacently when they learned of Sir William's address before the British Association for the Advancement of Science, feeling sure that the nitrate fields of Chile would never fail and that from that region the grain growers of many lands would always be able to get aplenty of that fertilizer of nature's making. Technicists, however, have not been of the same belief; and in view of the steady growth of the export of the raw material, it has been authoritatively said that the Chilean deposits will be exhausted by 1950.

Even if this be not true, it should be borne in mind that nature is not replacing what man is removing from those beds, formed ages ago when seismic convulsions pushed the Andes up from the depths of the ocean and carried the bottom of the Pacific, with vast quantities of seaweed, thousands of feet skyward, where that mass of marine vegetation decayed under conditions peculiarly favorable to the action of nitrifying bacteria.

A little over four years ago, the agricultural fraternity of the country awakened to the need of developing a domestic source of nitrates. The war in Europe had interfered seriously with the movement of saltpeter from Chile, over 4,000 miles away, and the demand of the Allies for more and more explosives and propellants had materially reduced our imports of sodium nitrate. Accordingly, our military services and the tillers of our soil united in asking Congress to appropriate for the creation of a new national industry—i. e., the fixation of atmospheric nitrogen; and an act was passed authorizing for this purpose the expenditure of $20,000,000. Subsequently, when we joined forces in that titanic struggle, we spent a far greater sum in the building of plants intended to draw nitrogen from the air and fix it in a form susceptible of use in the manufacture of munitions. But don't let us tangle the thread of our story. It is best that we learn first why the atmosphere will eventually save the day if the Chilean beds fail to meet the amplified requirements of the years to come.

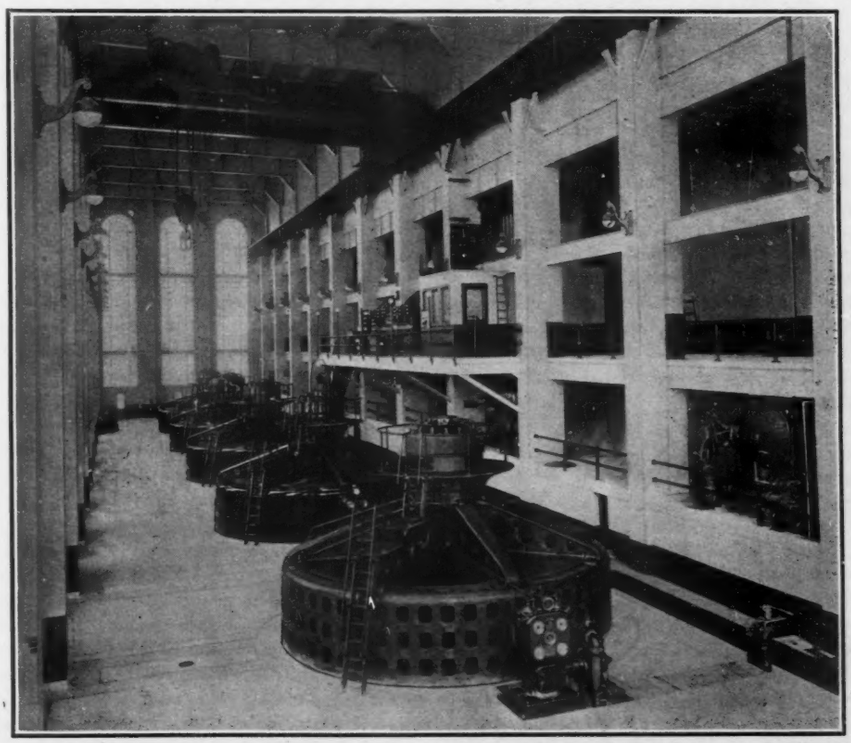
The air we breathe is made up principally of an admixture of oxygen and nitrogen; and nitrogen constitutes 79.1 per cent of the volume and 76.9 per cent of the weight of the globe's atmospheric envelope. That is to say, a column of air supported by a square yard of the earth's surface holds in suspension a matter of quite 5.8 tons of nitrogen. Something like 100,000,000 tons of this free gaseous element is stored in the soil by nature yearly through the action of electrical discharges in the air and the transporting medium of descending rains. Large as this quantity seems, still it does not suffice to revitalize those areas of the earth which are continually planted with exhausting crops.

However, this natural process of transference of nitrogen from the skies to the soil gave the man of the laboratory a hint of how he might, at will, duplicate the phenomena involved and produce nitrogen in a fixed form suitable to the various needs of human kind. But it was not until 1903 that apparatus were devised which would do this on a commercial scale; and credit for this achievement must be given to Christian Birkeland, Professor of Physics in the University of Christiana, and Samuel Eyde, a Norwegian engineer. It is true, that two Americans, C. S. Bradley and R. Lovejoy, anticipated the Scandinavians and actually built, in 1902, a plant at Niagara Falls for the fixation of atmospheric nitrogen, but the output of nitric acid was too small to make the undertaking a business success.

Bradley and Lovejoy as well as Birkeland and Eyde relied upon the electric arc as the basic feature of their systems; and to sum up their procedure in a popular way we may say that they resorted, in effect, to man-made thunder showers. When air is burned in the presence of intense heat, oxygen and nitrogen are converted into a gaseous product containing nitric oxide; and when these fumes are sufficiently cooled the nitric oxide unites with free oxygen and becomes nitrogen peroxide. But the primary temperature must be 5432 degrees Fahrenheit, and the electric arc is needed to insure this. When the temperature of the nitric oxide has dropped to 1148 degrees Fahrenheit, it will combine with free oxygen, form nitrogen peroxide, and lend itself to the making of nitric acid.

The next step in the production of nitric acid by the arc process, as practiced so extensively in Norway where the many waterfalls furnish electrical energy at very moderate cost, is to draw the nitrogen peroxide into great absorption towers built of granite. These structures are substantially filled with a mass of broken quartz through which water percolates downward from a spraying arrangement located at the top—imitating to this extent falling rain. The nitrogenous gas is forced into each tower near the base, and successively passes through three of these units before the cycle is completed.

In the first tower the descending spray becomes a very weak nitric acid by absorbing a percentage of the ascending gas; in the second tower, this dilute acid meets the rising nitrogen peroxide once more, taking up dur-



The great turbo-generators of our steam and hydro-electric plants will henceforth have a new significance to the people; they will provide current for the fixation of atmospheric nitrogen—thus enabling us to revitalize the soil and to prepare munitions for our defense.

ing the period of contact an additional amount of the gas; and this somewhat stronger nitric acid repeats the operation in the third tower, acquiring a greater amount of the nitrogen. By continuing these stages of concentration it is practicable to obtain nitric acid having a strength of 50 per cent. Plainly, further concentration can be effected by recourse to heat and the evaporation of the water.

The success of the arc process from a commercial standpoint is contingent upon the availability of low-priced current, because only a total of about 30 per cent of the primary heat of the arc is utilized to advantage, and not more than three per cent of the heat is effective in first bringing about a union between the nitrogen and the oxygen molecules of the air. In Scandinavia, heretofore, it has been possible for the consumer of electricity to get an annual horse-power at the astonishingly low rate of from two to three dollars; and this factor has been the controlling one in the profitable evolution of the comparatively inefficient arc process.

The achievements in Norway served the further purpose of stimulating interest in a new-born industry and inspired technicists and inventors in divers parts of the world to advance the art in one way or another. And here, again, we shall see how a laboratory discovery, aimed in an entirely different direction, blazed the way to another method for the fixation of atmospheric nitrogen—one that could make much higher returns in the quantity of nitrogen fixed for a given unit of electricity consumed.

Sometime in the "nineties" Professor Adolph Frank and Doctor Nicodem Caro, German chemists, were manufacturing cyanides, which were at that time opening up a new era in the extraction of gold from low-grade ores. In the making of their basic carbide, the Teuton technicists employed barium, which was rather expensive. The principal purchasers were operators in South Africa; and activities in the gold fields there were brought well-nigh to a standstill by the Boer War. A consequent slump in the market for cyanides threatened to ruin the business of Doctors Frank and Caro, and failure was certain unless they could find a source of cheaper carbides which, through the agency of nitrogen, could be transformed into cyanide. These men of the laboratory turned to calcium carbide, which was then being turned out in quantity for the production of acetylene gas.

Contrary to their expectations, Doctors Frank and Caro discovered that calcium carbide, when placed in juxtaposition with gaseous nitrogen in an electric oven, did not yield cyanide but, on the contrary, was transformed into a new chemical substance, i. e., calcium cyanamide, which possessed properties peculiar to itself. Later it was proved that calcium cyanamide was especially valuable as a fertilizer agent; and therefrom rapidly developed a peacetime industry which was to be of momentous importance to Germany, in particular, when her watchful enemies cut her off from supplies of Chile saltpeter during most of the years of the World War. Calcium cyanamide was then relied upon to supply the hard-pressed Teutons with much of the nitrates needed by them in the producing of propellants and explosives for their guns and projectiles.

For the making of calcium cyanamide or "cynamid," as it is termed under the proprietary patent rights, three fairly common raw materials are required: coke, lime, and nitrogen obtained from the free air. And the cyanamid, primarily a fertilizer, can be made to furnish, by proper treatment, ammonia which, in turn, will produce nitric acid when subjected to a catalytic process.

When we were brought face to face with the grim necessities of armed strife and were called upon to do our share in that awful struggle, we very wisely decided to place our main dependence on the cyanamid process for the fixation of atmospheric nitrogen, and at Muscle Shoals we created U. S. Nitrate Plant No. 2, a monument to engineering skill and constructive genius. That plant would not have been possible but for an American enterprise that had previously established kindred works at Niagara Falls, on the Canadian side, where a large block of electrical current at a moderate price was available.

The American Cyanamid Company built its plant at Niagara Falls during 1909, and, after a period of tuning up and experimenting, shipped its first finished material on the 1st of January, 1910. Step by step, technical difficulties of one sort or another were overcome, and finally, by 1916, the works were producing an annual total of 64,000 tons of cyanamid.

In passing, let it be said, that the cyanamid process requires, for a given quantity of fixed nitrogen, only one-fifth or one-sixth the electrical energy consumed in obtaining the same result by the arc process. This operative economy is of the utmost commercial importance, and bears directly upon the future of this novel industry within our boundaries. The cyanamid process of today does not differ in principle from that developed back in the days when Frank and Caro made it possible, but much has been done in the meanwhile in developing facilities that are now indispensable to the output of a high-grade commodity in large quantities; and the skill of Americans has lent much to these ends.

Now let us see just how cyanamid is made, and then take up its conversion, when desired, into ammonia and nitric acid. Crushed coke and calcined limestone are subjected to the high temperature of the electric furnace, where the heat registers 5432 degrees Fahrenheit. This serves to melt and to fuse both the lime and the coke, and while in a molten condition, the carbide, so formed, is tapped and allowed to flow into metal cars, each of a capacity of half a ton.

At U. S. Nitrate Plant No. 2 are twelve furnaces each capable of holding a charge composed of ten parts of quicklime and six parts of coke—the total weight being 1600 pounds. From the furnaces the carbide passes to a cooling building, where, when solidified and sufficiently chilled, the stuff is crushed and pulverized to make it fit for a maximum absorption of nitrogen.

During these operations the utmost care is exercised to keep the carbide away from water and the moisture of the air, lest acetylene be generated and a highly explosive mixture develop. To this end, provision is made by which the carbide can be crushed and milled in an atmosphere charged with nitrogen, which is an inert, non-inflammable gas. The nitrogen for this purpose is obtained from the liquid-air plant.

The curious will ask why, if the air about us holds so large a percentage of nitrogen, is it not possible for plant life to satisfy its needs by drawing directly from the atmosphere? The answer to this is that the nitrogen must be changed from the gaseous to a so-called fixed form and placed in the soil so that it may be extracted by the roots of vegetation.

Therefore, a very important part in the cyanamid process is first to garner the nitrogen from the air and to make it available in a pure state for absorption by the pulverized carbide. To achieve this the compressor is needful: first to liquefy the air and then to make it possible to separate the nitrogen from the oxygen by fractional distillation.

At Muscle Shoals the liquid-air plant contains fifteen twin-duplex units which supply air to 30 nitrogen columns at a pressure of 600 pounds to the square inch. The compression is carried out in three stages, i. e., 30 pounds, 140 pounds and 600 pounds. Compression produces heat, and expansion induces refrigeration. By alternating these processes the air is liquefied at a temperature of 380 degrees Fahrenheit, below zero.

The course pursued at U. S. Nitrate Plant No. 2 in substance is as follows: When the air has been compressed to 600 pounds it is allowed to expand by dropping to 50 pounds—setting up in doing so a condition of intense cold. The expansion of the air is brought about by using it to operate a small engine, and the exhaust from this machine is then led to an associate rectifier; the temperature of the engine discharge then being lower than the critical temperature of air, i. e., under 284 degrees below zero Fahrenheit. Into the rectifier, filled with cold air at a pressure of 50 pounds, is admitted a small quantity of air at a pressure of 600 pounds, and the effect of the latter is to induce liquefaction.

The next stage is to allow the liquid air to distill, during which the nitrogen is the first to vaporize and to return to a gaseous condition because it requires a lower temperature than oxygen to liquefy it. Accordingly, towards the top of the rectifier the nitrogen content is especially rich while at the bottom the oxygen factor predominates. To stimulate the distillation, the gas at the top of the rectifier is atomized with liquid nitrogen, which tends to precipitate any associate oxygen, and gaseous nitrogen is emitted from the apparatus for fixation purposes 99.9 per cent pure, so it is reported. From the liquid-air building the nitrogen travels by way of a 30-inch main to that part of the works where it is combined with pulverized carbide. Each nitrogen rectifier or column is capable of an output of 14,120 cubic feet of nitrogen in the course of eight hours.

Potatoes, Cotton, Wheat and Corn Crops Fertilized with Nitrogen

Fig. 1—With enough nitrogen in the soil it has been demonstrated that it is feasible to raise 625 bushels of potatoes to the acre.
Fig. 2—By proper fertilizing with a nitrogenous mixture it is entirely practicable to grow quite two bales of cotton per acre.
Fig. 3—Our loaf of bread and its price are contingent upon the presence of an ample quantity of nitrogen in the soil. Every pound of nitrogen restored to the earth will give a yield of twenty pounds of wheat.
Fig. 4—As many as 142 bushels of corn per acre have been obtained when a fertilzier rich in nitrogen was used.

But before we finish with the liquid-air phase of the fixation of atmospheric nitrogen by the cyanamid process, let it be emphasized that every precaution must be exercised to safeguard from impurities the air supplied the compressors. To this end, at Muscle Shoals, there are two big 30-inch pipes, running north and south from opposite sides of the liquid-air building for a distance of fully a third of a mile, with their intakes located where dust, fumes, etc., are not apt to reach them. Even so, this air is forced through sixteen scrubbing towers and there subjected to a cleansing process, by means of caustic soda, to make certain that the air is free from carbon dioxide which would interfere with the freezing operations incident to liquefaction. The liquid-air plant is five times larger than that of any kindred installation, and has a capacity of half a million cubic feet hourly.

Picture a building 520 feet long and 250 feet wide, and you have an idea of the extent of the structure in which are located 1,536 electrical ovens wherein calcium carbide is heated to incandescence so that it will absorb the nitrogen fed to it the while. Each of these furnaces is designed to carry a charge of 1,600 pounds of carbide; and for 40 hours it is held at 2,000 degrees Fahrenheit, which serves to bake but not to fuse it into a cake.

When the operation is finished the carbide holds imprisoned substantially 23 per cent of nitrogen, where it will remain until released by the action of water, moisture, or steam. In this state, when ground, calcium cyanamid possesses high fertilizing qualities and constitutes a soluble plant food, but is not yet a form of fixed nitrogen suited to the needs of the munition maker or to other industries.

To convert the cyanamid into ammonia gas —which can be used to manufacture aqua ammonia—the baked cyanamid is crushed and pulverized and then placed in steel tanks or autoclaves, where it is subjected to steam at a pressure of 150 pounds. This sets up a reaction which is allowed to continue for something like three hours, by which time ammonia gas is emitted. U. S. Nitrate Plant No. 2 has 56 autoclaves, each eight feet in diameter and twenty feet high, built of one and one-quarter inch steel so that they can withstand the internal pressure of 250 pounds, which is reached during the period that ammonia is generated. The installation is capable of producing fully 7,000,000 cubic feet weekly.

After the ammonia gas has been separated from the steam with which it is commingled on issuing from the autoclaves, and has been duly cleansed it is then ready for conversion into nitric acid. When mixed with

air, in the proportion of about one to ten, the gas is led to catalyzers in a separate building holding nearly 700 of these apparatus. Each catalyzer consists in the main of an aluminum box five feet high, with a cross section measuring fourteen inches by 28 inches, in which is placed a horizontal screen of fine aluminum wire made up with 80 meshes to the inch.

This screen can be heated by electricity to a temperature of 1,382 degrees Fahrenheit, and the purpose of this catalyzing medium is to convert the ammonia gas into nitric oxide—the same colorless gas produced directly by the arc employed in the Birkeland-Eyde method.

In passing, let it be said that the development of an efficient and reasonably rugged catalyzer has required much study and painstaking experimenting. Ammonia gas enters at the top of the catalyzer and is discharged into a suitable conduit at the bottom, whence it is led to oxidation towers, where it becomes nitrogen peroxide. From then on, the procedure, in effect, is akin to that followed in the arc process, where the nitrogen peroxide is absorbed by sprayed water and gradually concentrated by repetition of this action. When discharged from the last of the absorption towers the nitric acid has a strength of 50 per cent.

There are twelve oxidation towers at Muscle Shoals built of chemical brick, and the absorption towers are fashioned of the same material and are of like number. All of them are rather impressive structures and typically indicative of the splendid scope of the establishment. It is not the purpose of this article to carry the story of the fixation of atmospheric nitrogen further than to the point covering the making of nitric acid. It is enough for the present purpose to say that this acid, once available, can be utilized in the manufacture of explosives for war and peacetime services and for the production of dyes, celluloid, artificial leather, pharmaceutical preparations, chemicals, etc.

One does not have to be a technicist—a superficial knowledge of elementary physics will suffice—to make it plain that the outfitting and the successful operation of U. S. Nitrate Plant No. 2 involved engineering problems of magnitude and often of a puzzling nature. Remember, it was necessary to provide for the employment of temperatures ranging all the way from the heat of the dazzling arc to the freezing cold of hundreds of degrees below zero. Here were involved extreme conditions of expansion and contraction; and, to add to the physical difficulties, it was necessary to provide piping for the transmission of pressures reaching 600 pounds to the square inch. Leaky joints could not be tolerated, and yet rapid temperature changes had to be taken care of.

Similarly, it was essential that there should be well-nigh perfect insulation against heat or cold, as the case might be. As a matter of patriotic pride, the plant is a conspicuous example of skilful planning, fine execution, and amazing expedition. Gound was first broken on the 16th of February, 1918, and manufacturing operations were started eight months and eight days after work was begun. The rated capacity in ammonium nitrate, as proved by official tests, was more than 110,000 tons per annum—and therefore in excess of that specified by the contract. The works have been idle since the cessation of hostilities.

No description of the fixation of atmospheric nitrogen would be complete without reference to the Haber process, upon which Germany relied to give her 200,000 of her total of 420,000 tons of nitrogen annually within her boundaries at the close of the war. The Haber process is primarily the invention of Professor F. Haber, of Karlsruhe, and subsequently made commercially practicable by the Badische Analin-und-Sodafabrik, the great German chemical company of Ludwigshafen.

His aim was to produce ammonia by combining under a pressure of 175 atmospheres—i. e., 2625 pounds to the square inch—one volume of nitrogen to three volumes of hydrogen. To stimulate the union he had recourse to a temperature of 932 degrees Fahrenheit, which was maintained for a suitable period in the presence of a catalytic agent, powdered uranium. After ammonia gas was thus formed it was cooled to the point of liquefaction. In time it was found, that finely divided iron would answer admirably as a catalyzer.

Because high pressure plays an important part in the Haber process it is essential that the reaction chambers shall be of great strength, lest explosions be invited when the temperature is raised to the point described. Hydrogen, as all of us know, is very inflammable, especially in the presence of oxygen. Therefore, Professor Haber had recourse to steel flasks having walls two-tenths of an inch thick with an internal diameter of less than three inches. In actual practice, well-nigh innumerable reaction chambers, of a size

Using a hydraulic giant for extracting phosphate rock. This illustration shows one of the rock pits of the American Cyanamid Company, Brewster, Fla.

Courtesy American Cyanamid Company

A group of nitrogen columns in the liquid-air building. In these columns liquid air is distilled so that the vaporized nitrogen can be caught and separated from the oxygen and thus made ready for fixation with calcium carbide.

which can be held in one's hand, are used, and only carefully trained men are permitted to supervise their operation because of the hazardous nature of the work.

Largely owing to the fact that men of such training were to be had cheaply in Germany has it been feasible to carry on the fixation of nitrogen there by the Haber process. So far as the consumption of electric current is concerned, this method of fixation of atmospheric nitrogen is unique in the modesty of its requirements for the immediate formation of ammonia gas.

To provide the essential oxygen and hydrogen on a manufacturing scale a liquid-air plant is depended upon for the oxygen and an electrolytic installation for the hydrogen. A formidable array of compressors is indispensable for this service, as in the case of the cyanamid process, while a large group of electric cells is the medium by which hydrogen is obtained. At Muscle Shoals we called into being U. S. Nitrate Plant No. 1, designed to have an output of 22,000 tons per annum of fixed nitrogen. This factory was to operate a modified Haber process as controlled by the General Chemical Company. Because of the newness of the system, as evolved on this side of the Atlantic, a good many difficulties were encountered, and it seems that the works were "still in a somewhat experimental state when the armistice was declared."

So far as information has been given out, the fundamental difference between the practice of the Haber process in Germany and that as planned at Muscle Shoals was to utilize lower and less dangerous pressures in the reaction chambers. The catalytic agent, instead of being a mass of finely-divided iron, was a platinum gauze. Inasmuch as Plant No. 1 has cost us in the neighborhood of $8,000,000, it would appear desirable to run it at least long enough to demonstrate conclusively the measure of success attainable with the Americanized Haber process.

And now to bring us back to the days of peace. While both Plants Nos. 1 and 2 at Muscle Shoals were intended to meet a war crisis still the thought persisted the while that they should be used ultimately to turn out nitrates for fertilizing purposes. The importance of nitrates can be gathered if we bear in mind that of the three essential plant foods—nitrogen, phosphoric acid, and potash—nature is far less generous in placing ready at hand a sufficiency of the first named.

Our farmers pay more for nitrogen than for both of the other vitalizing chemicals; and, of the total outlay for these materials to enrich their fields, the husbandman expends twenty per cent for potash, 28 per cent for phosphoric acid, and 52 per cent for nitrogenous matter.

While it has been stated that the normal yearly requirements and consumption of sodium nitrate from Chile are slightly over 600,000 gross tons, of which quite one-half is used by the fertilizer industry, still the demand has been much augmented since that figure held good in 1913. During 1915, we imported 772,190 tons of saltpeter; in 1916, the amount was 1,218,423 tons; during 1917, we brought from South America 1,555,839 tons; and our imports for eleven months of 1918 reached 1,762,794 tons. Of the latter, no less than 1,100,000 tons went into the making of munitions; 215,000 in the preparation of chemicals; 185,000 in the production of commercial explosives; and a paltry 300,000 tons were left for the compounding of so-called artificial fertilizers.

Recently, Herbert C. Hoover, former Food Administrator, declared that we should be unable to export wheat a decade hence unless it was found practicable for the farmer to increase the productivity of his soil. And this brings right home to us wherein the output of our farms in certain staple products differs materially from the yield in some European countries. The better results abroad, generally ascribed to what is termed intensive cultivation, are mainly the consequence of a more generous application of fertilizers. The following table will substantiate this:

Country	Fertilizer Used per Cultivated Acre, 1910 Pounds	Average Yearly Yield Bushels per Acre, 1905-1913 Wheat	Rye	Oats	Potatoes
United States	37	14.6	16.0	29.5	95.0
France	111	20.2	16.9	30.6	130.7
Germany	207	30.9	27.4	53.6	204.8
Great Britain and Ireland	244	33.4	29.1	43.5	211.7
Belgium	495	37.0	34.7	71.5	306.0

It is a noteworthy fact that prior to their recourse to heavier fertilizing, the European farmers on an average obtained no bigger yields than their brothers in the United States. Within the span of a generation Germany speeded up her productiveness by grasping the importance of supplying her soil with a plenty of plant food. The results are amply demonstrated if we take the period between 1888 and the outbreak of the World War. Here are the figures:

AVERAGE YIELDS PER ACRE—BUSHELS

	United States 1888 to 1892	1905 to 1913	Gain	Germany 1888 to 1892	1905 to 1913	Gain
Wheat ...	12.8	14.6	1.8	20.2	30.9	10.7
Rye	12.9	16.0	3.1	15.8	27.4	11.6
Oats	25.3	29.5	4.2	33.5	53.6	20.1
Barley ...	23.5	24.8	1.3	24.8	37.2	12.4
Potatoes..	73.7	95.0	21.3	130.0	204.8	74.8

Plainly, to get the best out of our acres, no matter what may be the nature of the crop, we must have in one form or another a far greater measure of fixed nitrogen than heretofore, and this we can have beyond doubt if we adopt any process or processes which will lend themselves to American conditions. Up to date, the cyanamid process has shown itself best suited to the circumstances that dominate here; and in its facility of conversion into ammonia and then into nitric acid, cyanamid can be made to serve widely diversified demands. Cyanamid factories are today producing hundreds of thousands of tons of nitrogen in Norway, Sweden, Italy, France, Switzerland, Germany, Japan, and Canada. The world need no longer be as dependent as it has in the past upon Chile's beds of nitrate of soda.

Now that the United States can boast nitrate plants within its limits; now that we have a water-power law which offers encouragement to the development of hydro-electric sites, we have a prospect of an abundance of that moderate-priced energy which will make it feasible for us to draw more and more upon the enveloping atmosphere to furnish us nitrogen in a state which can be used for the many purposes already outlined. But don't let us forget that we have another native advantage when it comes to making our fields yield more plentifully so that we can take care of a vaster population while lowering the cost

of living. Let us recall that we have immense beds of pebble phosphate and much phosphate rock which, when combined with ammonia, can be converted into a compact fertilizer capable of insuring the farmer astonishingly rich returns for the labor and money devoted to his land.

In Florida, for instance, the pebble phosphate is obtained by hydraulic mining—streams of water, under an impulse supplied by powerful pumps, being the agency by which these prehistoric formations are attacked. The recovered pebbles are treated either by the electric furnace or acted upon by sulphuric acid in a way that brings about the formation of the desired phosphoric acid.

Happily for us, the years of denial, the years of self-dependence forced upon us by the war, have made us more fully alive to our own resources. Our men of science, our chemists, and our engineers have shown how we can help ourselves amazingly hereafter and, while strengthening our independence of foreign aid, make it practicable for us to enter markets abroad upon a scale heretofore quite out of the question. The fixation of atmospheric nitrogen as an industry is a departure in our realm of effort which will gather in value and in vital significance as time goes on.

AN INTERESTING AIR COMPRESSOR BOOK

WE HAVE received from the Vacuum Oil Company, New York, a handsome pamphlet of 28 pages, nine by eleven and one-quarter inches, devoted to and simply entitled "Air Compressors." It gives in limited space a very concise and complete account of all known types of mechanical air compressors and blowers, their varieties of design, construction and operation, with no suggestion of the product of any individual manufacturer. The illustrations are all pertinent and lucidly explanatory. The ingenious employment of colors in the cuts: yellow, for gas or air; green, for water; and red, for oil, is distinctly helpful. The topic of lubrication is fairly and intelligently treated, and is not given, as might have been expected, disproportionate prominence. We must suggest that the widely-held but absurd theory of the unlimited overheating of the air by the delinquencies of leaky discharge valves is somewhat overworked.

"Air Compressors" may be held for the asking, and will be found to be worth while.

THE TIDES TO WORK AN AIR POWER DEVICE

The following suggestion for an invention comes from a French writer in *Compteo Rendus*:

"Let a diving bell be fixed in the water. As the tide rises the water would ascend within it and compress the enclosed air. As the tides run out there would be an aspiration of air into the bell. Both the compressed and the rarefied air could be used to transmit power. The bell would be a sort of pump in which the piston, moved by the sun and moon, makes rather more than two strokes per day. The claim is made that such an arrangement avoids the drawbacks caused by the intermittent character and the inequality of the tides and that its manipulation would be chiefly a matter of cocks and sluices requiring the services of but few attendants."

It would be a waste of time to try to compute the great initial cost of the arrangement and the small amount of power which might possibly be developed.

INDUSTRIAL MOVIES

The films of the Bureau of Mines portraying the development of the coal and oil industries are such a pronounced success that numerous applications are being received for pictures of other activities. The films turned out are made under a co-operative agreement by which the industry furnishes the funds and the Bureau of Mines supervises the making of the picture. "The Story of Asbestos" is just being completed. "The Story of Sulphur" is in process of production. Work soon will start on a film showing the best types of insulation and how it may be used to prevent loss of heat. Several series of films might be suggested with compressed air as the dominant feature.

WASHED CARS DRIED BY AIR

Fisk & Davis, distributors for the Oldsmobile Co. at Modeste, Cal., have installed an improved method in the car washing department of their establishment. Instead of wiping the car dry with a chamois after washing it, they dry it with compressed air.

"This feature does away with all chance of scratching the finish of the car, says Walter Fisk, and it also gives a wonderful finish to the washed car. Wire wheel jobs are also cleaned with compressed air, and this makes a very neat and quick operation.

"Compressed air is also used for the cleaning out of the interior of the cars and the work we are turning out is creating much favorable comment. Our washers are handling a large volume of this work and this feature enables them to give a most prompt service in this department.

Personal Intelligence

Daniel F. Kellogg, a member of J. P. Morgan & Co. since 1913, died recently. He was formerly city editor and financial editor of the New York *Sun*, and widely known as a writer on financial and economic topics.

* * *

William C. Redfield, former Secretary of Commerce, was elected President of American Manufacturers Export Association at the annual convention of that organization held in New York, October 14.

* * *

F. P. Keppel, present director of Foreign Operations of American Red Cross, and formerly Assistant Secretary of War, has been chosen by the Chamber to be American Administrative Commissioner at International Chamber of Commerce at Paris.

* * *

E. Willoughby, Jr., has been appointed special advertising representative of the *The Professional Engineer*, Chicago, published by the American Association of Engineers, and T. S. Van Namen, formerly of the McGraw Hill Co. as Eastern representative.

* * *

William S. Peachy, vice-president of the Seattle National Bank, Seattle, Wash, died recently at the Faulkner Hospital, Jamaica Plain, where he had been taken as a result of a sudden attack of intestinal trouble while attending the convention of the Investment Bankers' Association of America.

* * *

Pres. Woodin of the American Car & Foundry Co. has been elected to the executive committee of the American Locomotive Co.

* * *

E. L. Hawes of the Ingersoll-Rand Co. has been transferred from the Duluth, Minn., district to Johannesburg, South Africa.

* * *

C. M. Keys has been elected president of Curtiss Aeroplane & Motor Corp., succeeding John N. Willys, resigned. F. H. Russell was elected vice-president. Henry G. Hitchkiss, C. R. Keys and J. A. W. Smith were elected to the board of directors.

* * *

William H. Vanderbilt and President R. T. White of the American Smelting & Refining Co. have returned from Europe.

* * *

Edwin F. Atkins has resigned as director of the American Sugar Refining Co. in order to devote his time to his own sugar interests in Cuba.

* * *

Arthur E. Morgan, chief engineer of the Conservancy at Miami, Fla., has accepted the presidency of Antioch College at Yellow Springs, Ohio.

* * *

W. R. Harvey, has joined the force of *Industrial Power*, Chicago, as Western advertising manager, with headquarters at Chicago. For the past five years Mr. Harvey has been a representative of *Literary Digest* in the Chicago territory.

* * *

L. D. Van Doran who has been publicity manager of the Audit Bureau of Circulations, Chicago, has joined the staff of *Petroleum*, Chicago.

* * *

George A. Brown, former Philadelphia manager of *The Purchasing Agent*, New York, has been transferred to the New York office as advertising manager.

* * *

Walter S. McGrane, formerly in the copy service of the McGraw-Hill Company, Inc., specializing on Engineering News Record accounts, has joined the Service Department of the Material Handling Cyclopedia, published in New York.

* * *

Mr. Jack Walsh, who for a number of years was general manager of the Robert Grace Construction Company, and also connected with the Harmon Creek Coal Company, has taken charge of the John F. Casey Stripping properties on the Pennsylvania Railroad near Burgettstown.

PNEUMATIC CONVEYERS OF FINE MATERIAL

AT A RECENT conference of the Engineering Group of the Society (British) of Chemical Industry, held at Birmingham University, the special subject of discussion being *Labor Saving Devices in Chemical Works,* two interesting papers were presented having to do with the pnuematic lifting and conveying of coal and other materials. These devices, by the way seem to be much more extensively employed in Great Britain than in America.

A Suction Plant

First were given the details of a pneumatic suction plant in connection with the power house at Messrs. Boots Pure Drug Co., Ltd., Island Street, Nottingham. This power house is surrounded by the large chemical factories of the same firm, and it was very essential that all dust should be eliminated in the unloading of coal for use in the central power house. The problem was to move 20 tons an hour of coal of a quality from fine slack to lumps up to fully 4-in. cube to a central bunker. The supply of coal was principally brought by barges, but provision was made on the opposite side of the power house for a supply of coal from other collieries by means of road transport. The intake hopper or storage bunker is situated at a height between 70 to 80 ft. from the water level, and it consists of a wrought iron bunker with numerous outlets to the boilers below, but with sufficient capacity to contain 400 tons of coal.

To perform this duty, the suction plant consists of: First, a pump 28 in. diameter by 14 in. stroke. The pump is what may be termed a "dry air pump," having Corliss inlet valves and leather expansion valves. This pump has been tested by taking the air indicated horse-power against the electrical horsepower and gave an efficiency of 78 per cent. It is provided with ring oiling bearings and lubrication arrangement for continuous working. Close to the pump is provided an elaborate dust collector consisting of sixteen flannel bags providing a large area for filtering the dust from the air before reaching the pump. The bags are placed vertically and the incoming air is given a vertical downward direction. The bags are open on the inside to the incoming air and the collector is provided with a large chamber at the top and a large chamber at the bottom, the bags themselves being open at each end. The air passes out radially from the bags before reaching the pump. The direction of the incoming air vertically descending allows a large quantity of the particles of very fine dust to be precipitated straight into the bottom chamber, as the velocity of the air is approximately 40 ft. per sec. On the bottom of the dust collector is provided an automatic discharge valve, which automatically discharges into bags any dust that drops through the bags. There is also provided a circular scraper, which sweeps down the conical section and automatically cleans the dust collector. This very fine dust is collected in bags and sold to the foundry trade for dressing moulds, and has proved to be a useful by-product to any coal suction plant.

The pump and the dust collector are placed on the ground level in a separate engine house, and from the dust collector to the actual discharge over the bunker is approximately 100 ft. of 10-in. steel piping and special swelled bends of 10 in. to 13 in. diameter. The swell bends are to allow for an easy travelling round of each bend to prevent frictional losses.

The coal discharger itself consists of a cast iron vessel with two King's patent rotating valves in the form of a slightly conical taper divided into four sections, one portion of the circular valve being under vacuum, and the other under ordinary atmospheric pressure. The outlet of the valve is larger than the inlet, to allow for the coal which is in the valve to drop out easily. Over each valve is also provided a four-armed sweeper to prevent any fine damp coal forming a cone inside. This discharger is provided with two inlets with fullway bored valves, so that the coal can be either drawn from the water side or from the land side at will. After the coal has been deposited in the main discharger, there is provided a supplementary discharger, consisting of a vessel 6-ft. high by 30-in. diameter, with two inlet pipes of 8-in. diameter to provide a contra flow, so that any particles of the coal dust in the air will meet one another in the 30-in. box, and in practice hit one another at an equal velocity, so that the small particles will be deposited by a supplementary discharge valve which is set to run very much slower than the main discharger valves.

The size of the intake pipes for the coal is 5-in. diameter, and they are provided on the bends with heavy cast iron, with extra thick metal on the outside, which counteracts the wear of coal passing at the rate of 20 tons an hour. The pipe into the barge is provided with a flexible connection, and both flexible steel pipe and India rubber piping have been used to couple up the nozzle to the vertical line pipe. This nozzle is made as light as possible for easy handling, and has an air intake pipe for the regulation of the quantity of air necessary to blend with the coal.

In regard to the theory of how 3 lb. of vacuum can lift 1-lb. weight of coal 80 ft. at the rate of 40 ft. per sec., the explanation is that inside the pipe what takes place is a continual whirlwind, and in the range of the piping a gradual increase in size is provided in order to allow for the expansion of the air under vacuum, as between the coal barge and the pump.

In addition to the duty of lifting coal from barge and from the land side, when no coal is required the plant can be used for the withdrawing of ashes from the ashpit, also for the fine dust from the back of the Babcock and Wilcox boilers, also flue dust from the economizer chambers. A supplementary discharger is then provided outside with ash hopper together with supplementary discharge valve, also with a water feed to quench any live ashes that may be taken over.

Although the average working vacuum is 10 in. of mercury, the pump can maintain a vacuum of 18 in. with extra power being allowed in the event of any extra duty being required for coal that may be damp, either due to leaks in the barges or bad weather in transit from the colliery to the power house. In practice it is usual to allow two horse-power per ton per hour, but it is possible on certain classes of coal to get one and three-quarter horse-power per ton per hour; this varies slightly owing to the human element being required to keep up constant feeding of coal to the nozzle by trimming, and in a long narrow barge there must be a certain amount of movement allowed for to get the nozzle to the different parts of the boat.

The plant has been running now for fully 18 months.

The second paper, on the *Pneumatic Conveying of Granular Substances, including Chemicals,* was read by Mr. Gordon S. Layton, of Messrs. Robert Boby, Ltd., Burg St. Edmonds.

Pneumatic Conveyer Limitations

He said it was now recognized that the pneumatic conveyer was not suitable for all circumstances, and that under certain conditions it would not compete with the well-known band type of conveyers and bucket elevators. Where it was a question of conveying or elevating material from one definite point to another definite point, then, under ordinary circumstances, the lower power consumption of bands and elevators gave them a decided advantage; but where the material had to be gathered from a large area, as, for example, the hold of a ship or a storage floor, then the wages cost in bringing the material to a bucket elevator far outweighed the saving in power, and the fact that the suction nozzle of a pneumatic plant could be brought to the material with little or no difficulty, resulted in such a reduction in the wages bill as more than pays for the extra power consumption. Further, when it was necessary to convey material across obstacles, such as streets, railways, rivers, etc., the pneumatic conveyer offered great advantages owing to the ease with which a pipe-line can be erected and supported.

The ratio of the average capacity to the maximum or nominal capacity is considerably higher with the pneumatic conveyer than with the bucket elevator. Thus, with 100 tons per hour maximum capacity in each case, the pneumatic conveyer will unload a cargo at an average over-all rate of 70 to 75 tons per hour, while the bucket elevator will not exceed 55 to 60. This point is of great importance for waterborne materials, as it cuts down the time of unloading and therefore reduces demurrage. Other advantages are to be found in dustless working, greater independence of labour and independence of weather and tide conditions.

When the pneumatic conveyer was first introduced it was apparently considered that a solid core of material would be carried along the pipe, either by suction or by pressure; the result of trying to attain this idea was that the power consumption of the early plants was very high indeed. Later on, the Germans showed that this idea was quite incorrect and that much greater efficiency could be obtained by conveying a comparatively small core of material in a large stream of air. The conveying is effected through friction between the

air and the skin of particles conveyed, and this friction results in an expansion of the air.

Reciprocating Exhausters Preferred

For exhausting the air it is usual to use either piston pumps or blowers. The latter may be either of the Roots type or of the newer turbo-exhauster type. The Roots blower is considerably the cheapest in first cost, but unfortunately its efficiency falls off very rapidly when approaching the vacuum at which all conveying plants are designed to work. It is, therefore, very wasteful in power as compared with the amount of material conveyed. As regards the turbo-exhauster, this machine has only been developed recently, and in its present form suffers from the same fault as the Roots blower, but in a much milder degree. Neither of these machines is as suitable as the piston pump, except perhaps in the case of very small plants. The pump used for pneumatic conveying is quite different from the ordinary type of vacuum pump, the requirement being to displace a large volume of air at comparatively low vacuum rather than a small volume of air at a high vacuum. It is necessary that the piston and cylinder of the pump shall be so designed that the presence of dust in the air will not result in undue wear of the walls of the cylinder; as the dust would combine with any lubricating oil and form an exceedingly abrasive compound, it is necessary that the lubrication of the piston ring shall be effected without the use of oil; this result is achieved by the use of graphite plugs in the piston ring and in various other ways. Seeing that the pump is called upon to handle large volumes of air, the design of the valves and the provision of easy inlet and outlet passages is a matter of great importance. With the above exceptions, the design of the vacuum pump does not differ from that of any good reciprocating engine.

As all granular substances are accompanied by varying amounts of dust, it is necessary to separate more or less of this dust from the air before its entry into the pump. There are two usual methods of effecting this: Firstly, a cyclone of the well-known type placed inside the receiving vessel, and secondly, filters containing tubes of closely woven fabric. In the case of large plants, it is impracticable to supply a battery of filters of sufficient size and there is no alternative to the use of a cyclone.

There are two types of discharges in use. The first consists of a large steel box divided by a vertical partition into two compartments. This box is arranged to oscillate about a horizontal axis, so that each compartment alternately is brought under the lower opening of the receiving vessel. The other type of discharger consists of a bucket wheel rotating continuously inside a closely fitting casing. The material which is being conveyed falls into the pockets of the bucket wheel when these are on the top of their revolution, and is passed out through an opening in the lower side of the casing. In each case special mechanism for driving the discharger has been devised, to avoid the interruption resulting from blocking, and to enable the discharger to keep on working continuously. The rotary type of discharger is preferable to the tipping box type, for the following reasons: (1) That the discharge takes the form of a practically continuous stream, while that of the tipping box occurs as large isolated masses of material; (2) that it is more easily kept air-tight; (3) that it works without any vibration.

The design of the transport line is one of the most important points in a pneumatic conveying plant. It is necessary to keep the transport lines as straight as possible, as bends hinder the flow of the material along the pipe, and therefore result in an increase in the power consumption. In a well-designed plant joints of various types are used, by means of which the transport line can be moved as a whole, either horizontally or vertically, so as to enable the nozzle to reach a large surface of the material which is being transported, while still retaining a straight transport line. The use of flexible hose could not be dispensed with entirely, but the extra cost of the joints in the transport line necessary to provide a wide range of movement is amply repaid. In the case of large plants, the bends are usually so constructed that the side of the pipe forming the outer radius of a bend can be readily renewed.

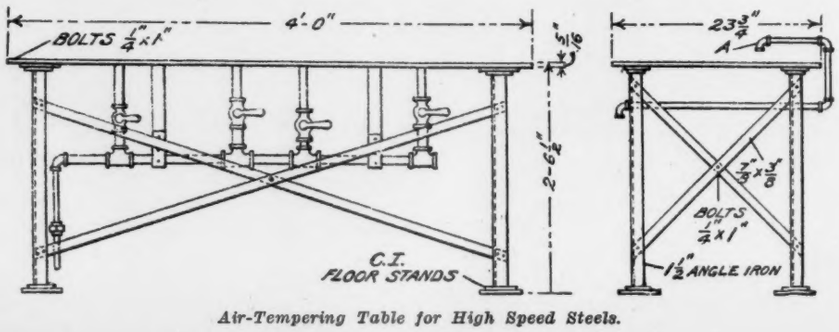
More patents have been taken out for improved types of nozzles than for any other detail in a pneumatic conveyer. Special forms of nozzle may be used with advantage in awkward positions, such as corners of a ship's hold, or for dealing with special materials, such as damp coal dust, cement, etc., which have a very steep angle of repose.

The usual form of intake line contains a vertical lift of 40 to 50 ft., with a horizontal distance of up to 35 ft. This is the type of plant which is commonly used for unloading ships, the material being deposited just inside the building.

AN AIR-TEMPERING TABLE

The advent of the modern tool steels, which brought with them the possibility of high speed metal cutting and all its accompaniments of increased efficiency brought also its perplexities to the blacksmith who forges and tempers the tools. The steel, as a rule, when heated cannot be quenched in water for hardening, as has been the time honored practice with the carbon steels, but must be cooled by jets of air. This being a novel requirement no provision existed for performing the operation satisfactorily, but this is now being provided for.

The accompanying sketch, which is almost entirely self explanatory, shows an air tempering table in use in the Watervliet shops of the Delaware & Hudson R. R. Co. It is formed of a plate of steel 5-16 in. thick standing on four legs made of angle iron with cast iron flanges. The air is carried along beneath the table in a pipe with four branches rising and passing up through the plate, each being provided with a stop valve. The tools may be placed on the table above a jet coming up from below, or as they lie on the table they may be cooled by a downward jet at A delivered by the pipe running up at the back of the table. The arrangement, it will be seen, is very simple and may be easily duplicated with such variations as the requirements may suggest.



Air-Tempering Table for High Speed Steels.

THERMOMETERS ARE MORTAL

Even thermometers, says the *Scientific American,* become old, and consequently inaccurate with age, mercurial instruments reading too high and spirit instruments too low. In the former case the bulb appears to shrink, thus forcing the quicksilver too far up the stem. This gradual shrinkage is supposed to be due to the fact that the external pressure on the bulb may be considerably higher than the internal pressure, the air as far as possible having been removed before the glass is sealed off. On the other hand, the spirit thermometer is sealed with the bulb covered in a freezing mixture, in order to lock up in the glass as much air as possible. The instrument thus starts with an internal pressure which in time appears to be reduced either by expansion of the glass under the internal pressure or by leakage.

OIL IN MEXICO

According to an official report on the oil industry of Mexico, there are at the present time over 770 miles of pipe line in use. These lines have a daily capacity for transporting 382,016 cubic metres of oil, or more than two million of barrels. There are now in the petroleum zones a total of 1103 wells, of which the number in production is 305. In this connection Mexico has the largest well in the world, the Cerro Azul No. 7, which produces 370,000 barrels daily. There exist about 900 tanks used for the storage of the petroleum destined for immediate exportation, and it would appear that the equivalent of about $50,000,000 is invested in the industry.

Compressed Air as a Teacher and Demonstrator

How One of the most Comprehensive and Renowned Mechanical and Scientific Exhibits in the World at the Famous Museum, South Kensington, London, Employs Compressors in an Important and Novel Role.

By Ben K. Raleigh

TEACHER and demonstrator is the important and novel role assigned to compressed air in one of the most comprehensive and renowned scientific exhibits in the world.

In the South Kensington Museum, London, a British national institution conducted under the authority of the Board of Education, dozens of fascinating models of mechanical apparatus dating from the time man first dreamed of obtaining horse-power—without the horses—down to the present era of intricate and complex motor invention, are displayed for the benefit of students, scientists, and engineers who come from the four corners of the earth to see the famous chronological collection representing the various stages in the progress of mechanical engineering. And the models are operated by compressed air.

The Ælopile, a reaction steam turbine, built by the painstaking workmen of the Museum on the lines laid down by Hero of Alexandria, A. D., 50, in his treatise on pneumatics, revolves with a speed and regularity that would have delighted and mystified its ancient inventor. It is no conception of Hero's which provides the motion. It is compressed air—modern, twentieth-century genius harnessed to demonstrate with exactitude the hoary, first-century principles of a theorist as dead as an Egyptian mummy. This exhibit alone, showing the alpha of antiquity motivated by the omega of modernity, sums up the mechanical advancement of the engineering world in a nutshell; or in a glass case, to be more precise.

The conspicuous success with which this new use of compressed air has been attended is attested by the officials at the Museum, and the greatly enhanced value of the exhibits to students since the installation of compressed air machinery is emphasized by them.

To be able to watch and study at leisure and in detail the workings of queer and historic models by the mere pressing of a button, which otherwise would have to be imagined or guessed at, is a clear gain which compressed air has contributed to the study of the science of engineering. It is an advantage which the crowds gathered daily around the models prove is fully realized and appreciated. British and Colonial students, an American and Frenchman or two, invariably a Japanese, to say nothing of the usual quota of small boys, form the nucleus of the interested spectators.

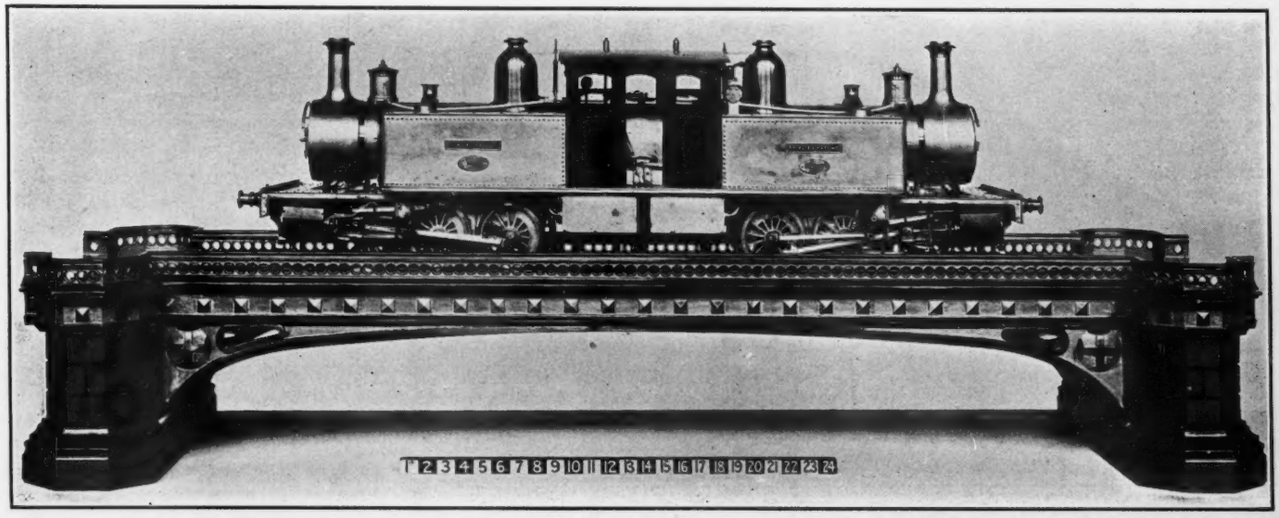
There are, roughly, 80 mechanical models of the utmost interest to engineers which are operated at will by the power of compressed air. Each case containing such a model has its little push wire fixed in the bottom moulding and the man desirous of seeing the wheels go round and studying the mechanical structure has only to lay his thumb on this wire and instantly the ever-ready, never-failing genii, compressed air, is at work and the performance begun.

Through the courtesy of Major T. F. Parkinson, Keeper, and of Mr. Overton, of the Science Museum staff, I was able to explore the depths of the Museum where the compressed air genii has its cave.

The machine used is a rotary compressor, supplied to the Museum by Messrs. Reavell & Co., Ltd., of Ranelagh Works, Ipswich, with London headquarters at Queen Anne's Chambers, Westminster. It is of the type termed by the makers a "rolling drum rotary compressor." The compressor which is the Reavell R. 8x8, has a displacement of 210 cubic feet when running at 1,000 revolutions, which can be increased up to 268 cubic feet at a speed of 1,400 r.p.m. The pressure required to operate the models is six pounds per square inch and the actual power absorbed varies from six horse power to a little over nine, depending on the speed at which the compressor is run.

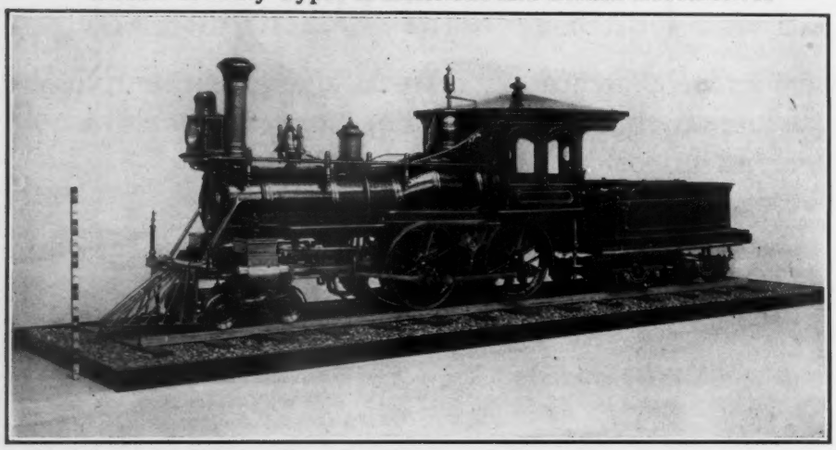
The compressor is direct-coupled to a motor of ten horse power running on a 220 volt d. c. circuit. With the motor compressor set is a Brook-Hirst combination control panel No. 11, comprising a starter with no volt and overload release coils, a shunt field regulator to give the required speed variation and a double pole switch and fuses, with an ammeter to show the amount of current passing to the motor.

To my mind the greatest compliment and recommendation that could be paid by science to compressed air is the fact that this new installation continues the use of compressed air service at the Museum, supplanting with the electrical device the operation which has

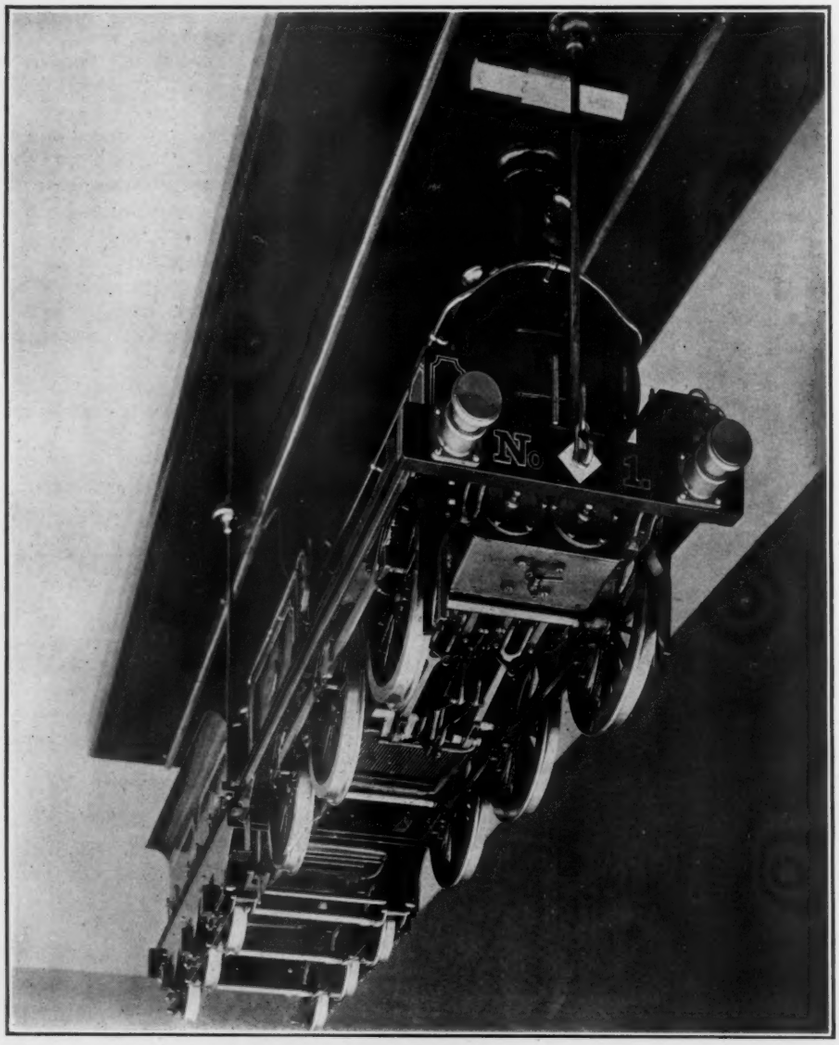


Compressed air operates this model of Fairlie locomotive in Science Museum, South Kensington, London. It is rather interesting in that it embodies the leading features of R. F. Fairlie's arrangement, patented in 1864 by which a large amount of traction power is obtainable from a locomotive that could work on a light rail and pass round sharp curves. The boiler is mounted on the center of two frames, each forming a complete engine distinct in itself, but both receiving steam from the common boiler which is of considerable length and has two fire boxes near the middle with a chimney and a smoke box at each end. The gears of the two engines are coupled up, so that they are instantaneously controlled by a single reversing lever. The idea in having such a locomotive fitted for running in either direction was to avoid the use of turn tables. The peculiar bridge on which the model is shown was made to demonstrate the flexibility of the wheel base and also to facilitate inspection of the model when the compressed air button is pressed and the wheels begin to whirl.

Models of Early Types of American and British Locomotives



Model of an American type locomotive. Compressed air makes its wheels go round for the edification of Englishmen at South Kensington Science Museum, London. This photo represents a passenger locomotive built about 1875 for the Erie R. R. and is of the then typical American construction with outside cylinders, four coupled driving wheels and a leading bogie. The "cow catcher" always excites interest and amusement in England. In the photo it will be noted that there is a portrait insert on the boiler head. This is a picture of General U. S. Grant.



Model of a six coupled goods (freight) engine worked by compressed air in Science Museum. This represents an inside cylinder engine with six coupled wheels of four feet diameter. The cylinders incline slightly downward, so that while high enough to clear the leading wheels, they act directly on the central driving axle, which has two cranks at right angles and also the four eccentrics of Stephenson's link motion. The cylinder slide valves are above the cylinders and receive their motion through a weight shaft. The feed is supplied by a vertical fly-wheel donkey-pump at the side of the fire box, this model having been made before the general use of the injector. The method in which three axles are coupled up so that the adhesion of all six wheels is utilized for traction is also clearly shown and demonstrated by the use of compressed air. The tender is fitted with six wheels and provided with a powerful hand-brake.

been in uniformly satisfactory and successful operation since 1891. In that year the orginal compressor was installed in the Museum. Those were the days when the compressor was driven by a belt from a gas engine and had a capacity of 70 cubic feet per minute. So pleased were the fastidious Museum authorities with the result of this—for a conservative Museum—rather daring experiment, that in 1895 a larger plant was installed, which was directly connected with a gas engine and had a capacity of 125 cubic feet per minute. A pressure of about five and one-half pound per square inch was employed and the air passed from the compressor to a receiver which held about 45 cubic feet and was provided with a relief valve for regulating the pressure.

This worked so splendidly, in enabling the Museum to fulfill the highest functions of an institution of its kind—the display of working models operated at the will of the visitor—that the improved electrical installation was decided upon and it is now purring contentedly and efficiently in the basement of the Museum.

The compressed air is distributed to various parts of the Museum Galleries by means of gas piping varying in diameter from two inches to one-quarter inch. The piping runs beneath the flooring and branch pipes run up to the centre of the floor of the display cases. Where more than one working model is contained in a case rubber hose is employed to bring the air from the pipe as it enters the case to the different models ranged about the sides.

The compressor is of the crescent type—that is to say, a drum fitted with a number of slots in which steel blades slide in a radial direction—and revolves in a casing in which it is placed eccentrically. The great drawback to such an arrangement has been that the pressure set up by the centrifugal force along the tips of the blades caused a great deal of friction which resulted in excessive wear both to the blades and to the casing and produced a considerable amount of heat by reason of the high rubbing speed along the inner surface of the stator. In consequence, machines of this type had usually to revolve at very low speeds and this defect rendered them unsuitable for a direct form of drive.

This defect was overcome in a rather ingenious way by the firm which made the installation at the Science Museum. Instead of being forced against the bore of the stationary casing the blades press against the interior of a liner, which revolves on ball bearings concentric with the casing. The outside diameter of the liner is slightly less than the bore of the casing, so as to leave a small clearance between the revolving and the stationary portions of the machine and thus to prevent any rubbing effect. When running the centrifugal force created in the blades forces them outward against the liner, and the friction produced at the tip of the blades is obviously much more than sufficient to overcome the slight frictional resistance in the ball bearings. The liner therefore revolves freely with the drum or rotor.

There is a small amount of relative motion between the blades and the revolving liner, since the tip of a blade at the top of the crescent has a greater tangential velocity than the blade diametrically opposite. As a consequence, the liner takes up a certain mean speed, which inevitably leads to a slight relative motion between the blades and the liner, but this small movement is almost insignificant as compared with the surface speed of the blade tips if they were to rub against the wall of a stationary casing. This fact enables the normal speed of the machine to be raised very considerably and thus renders it suitable for direct coupling to electric motors and other forms of high speed engines.

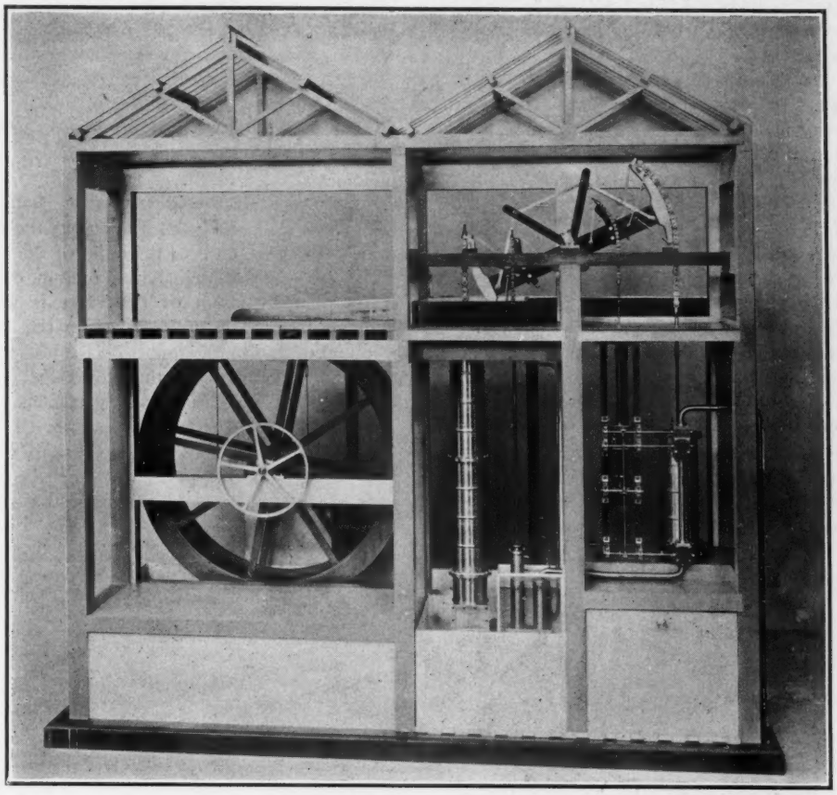
The question of economy of operation is an important one for every one, but especially for a museum, which usually is obliged to conduct its operations on insufficient appropriations from the public purse. It is interesting to note, therefore, that the first compressor installed in the Museum, a Scott compressor, cost 65 pounds sterling, that the second compressed air plant, a Crossley installation, cost 200 pounds sterling (in 1895) and that the latest, in this era of high costs of materials and labor, only cost the Museum 275 pounds sterling. Electric operation is found to be much more economical than gas.

One point that was made by Mr. Overton in my conversation with him was that the pressure used to operate the models was never more than six pounds, for the reason that at a higher pressure moisture was caused to condense on the glass of the exhibit cases and so to obscure the workings of the models. But they all—and I tested each personally—work quite satisfactorily at the six pounds pressure.

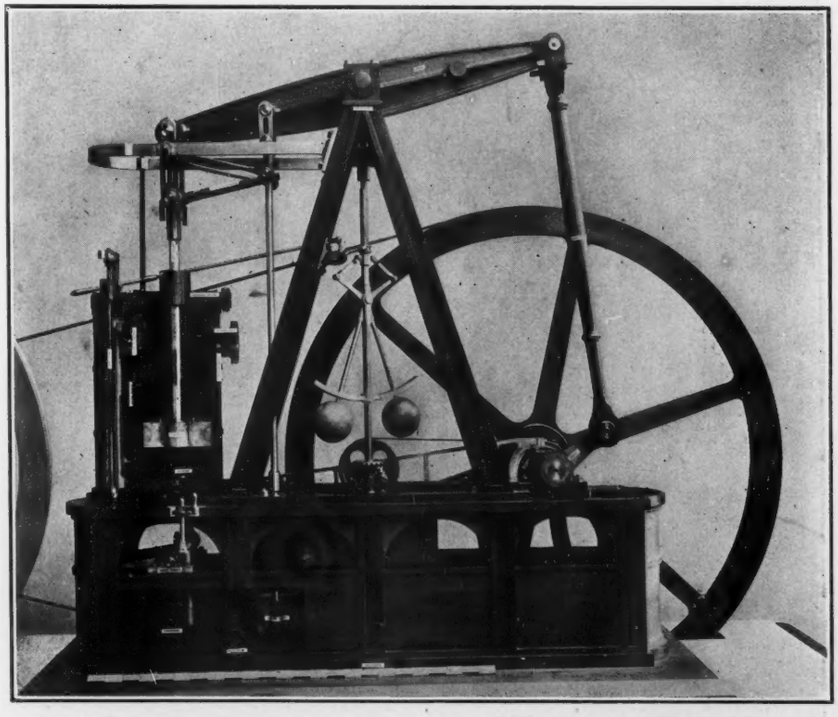
An examination of the models and the other mechanical treasures in the Science Museum is a joy to the lover of mechanics. The splendid collection housed at South Kensington was commenced in 1867 by direction of the Lords of the Committee of the Council on Education with the view of affording in the best manner possible, information and instruction on the immense variety of machinery in use in the manufactures of England. A very valuable addition, consisting of models made by James Watt himself, or his workmen, was in 1876 presented to the Museum by Messrs. James Watt & Co. A further large accession of machines and models was received from the British Patent Office Museum when, in 1884, that Museum was discontinued. From time to time purchases of particularly interesting objects have been made, but to a very large extent the collection has been assisted by gifts and loans of machinery, models and drawings from manufacturers and inventors and it continues to rely mainly on such sources for its augmentation.

The interest which the use of compressed air has in connection with the working of the models is best illustrated when it is stated that it is not the object of the Museum to indicate the present state of the arts in any particular branch of engineering. Its aim is rather to illustrate broadly the steps by which advances have been made up to the present day; to show students at the same time the general principles which underlie all its branches, and to of-

Early Types of Engines Including "Old Bess" Invented by James Watt



Model of the "Old Bess" engine of James Watt working in Science Museum by the use of compressed air. This model which has been constructed from the data given by the existing portions of the engine together with those of two early drawings, shows the arrangement of the engine erected at Boulton's works at Soho in 1877.



A sectional wooden model of a beam engine in South Kensington Science Museum, London. It is one of the most attractive models in the Museum as the sectioning enables the engineering student to watch and comprehend every movement as the engine is being operated by the force of compressed air. The model is a copy in wood of Watt's rotative beam engine sectioned to show the internal construction. The valve is of the long D type which was patented in 1799 by William Murdock of the firm of Boulton & Watt, but which was not introduced until after 1800, when Watt, who preferred the drop type of valve, had retired. The live steam is always around the waist of the valve.

fer to the engineer suggestions or ideas from other branches of his profession that may prove fruitful in the work upon which he may be engaged.

Let us now come to an extremely interesting part, that part which refers to the character of the models operated by compressed air. The Hero model has already been referred to. This, of course, is of prime interest because it constitutes the conception of present day engineers of the apparatus described by Hero. A few steps away is an organ blower. This, in the original, is a water pressure engine designed for working the bellows supplying air to an organ, but the cylinder in its action resembles the steam cylinder of a direct-acting steam-pump.

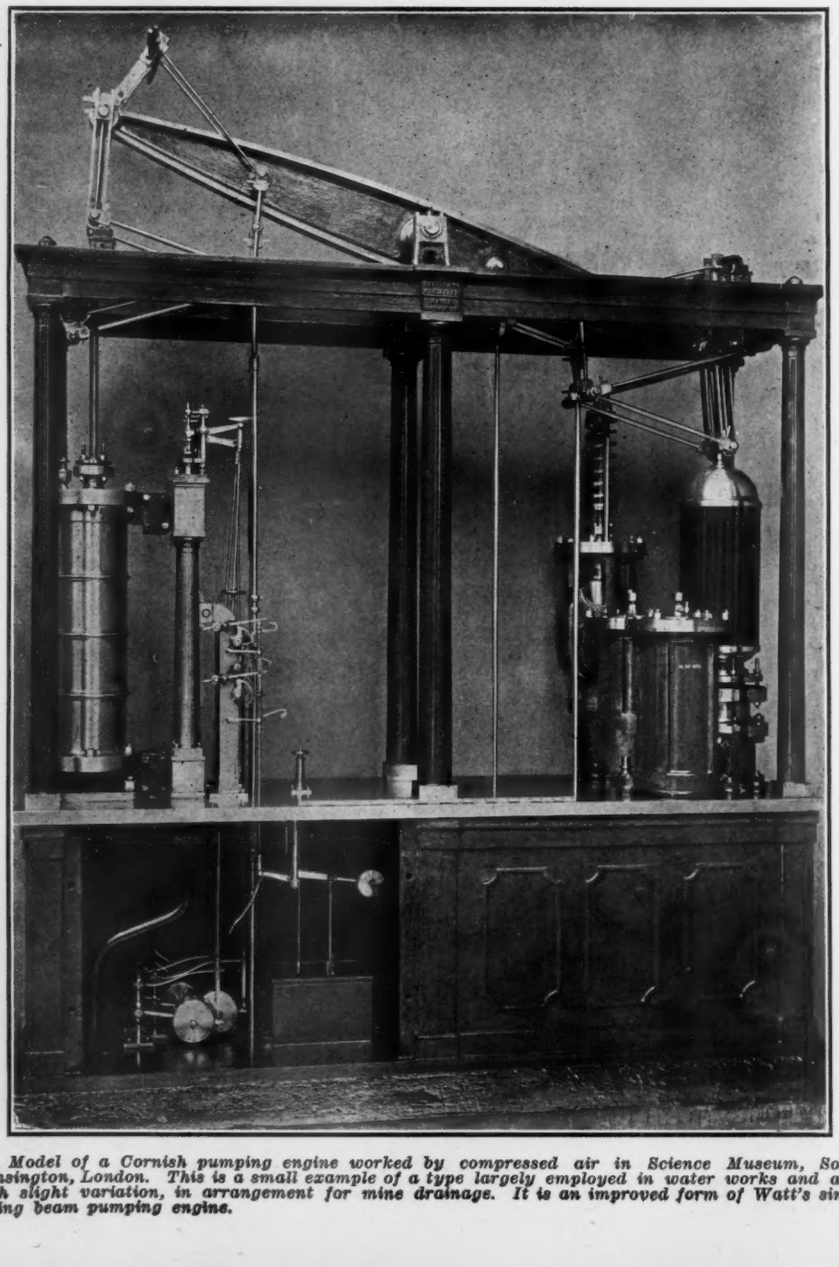
The supply of water is controlled by a valve connected with the air receiver, so that the speed of working is automatically adjusted to the consumption of wind. The blower model shown has a cylinder 5.5 in. diam., by ten-inch stroke, and is fitted with a valve gear. The piston rod is directly attached to the bellows, but has on it a tappet which reverses the distributing slide valve on the completion of each stroke. This slide valve is of the piston type, but in reality two valves combined in one, for by its sliding motion the valve acts as the main slide valve, while by a rotary motion through twenty degrees it acts as a plug valve which does duty as an auxiliary valve.

The plug is in the middle of the length of the piston slide and by its motion lets the water to and from the ends of the chest of the piston valve, so causing the sliding motion of this valve. The rotation of the valve is caused by two inclined horns, secured to the valve-rod and moved by the tappet on the piston-rod.

There is the model of the "Old Bess" engine (scale 1:12) made in the Museum in 1894. This model, which has been constructed from the data given by the existing portions of the engine, together with those of two early drawings, shows the general arrangement of the engine erected at Boulton's work at Soho in 1777. It embodied the first improvements made by Watt upon Newcomen's pumping engine. James Watt's first steam engine was constructed and tried at Kenneil, in Scotland in 1769, and was sent to Birmingham in 1773. At Kenneil the engine, although it had a separate condenser and embodied other improvements, was hardly a success, owing to the defective mechanical construction. When Watt joined Boulton the engine and boiler were conveyed from Scotland by water via Hull to Birmingham and for two years the engine was being rebuilt and improved, until with a new bored cast-iron cylinder, it worked fairly well.

It was known as "Beelzebub" and had an eighteen-inch cylinder, five-foot stroke and worked an 18.5 inch pump against a 24-foot head. In 1777 it was destroyed by fire, but "Old Bess" was constructed immediately afterward to do the same work as the destroyed engine; it was, however, of considerable more power, as the steam cylinder is 33-inch diameter with a seven foot stroke and the pump has a diameter of 24 inches.

Matthew Boulton, when James Watt first knew him, was an extensive manufacturer of ornamental articles, and to drive his metal rods and polishing machinery he used the power of two water wheels which, in dry weather, were assisted by from six to ten horses. "Old Bess" was constructed to pump water from the tail-race back into head-race of a water wheel of 24 feet diameter and six foot breast at times when the stream flow was insufficient. This indirect method of obtaining rotary motion by steam power had previously been employed in London and elsewhere. Long after the introduction of the rotative steam engine, however, this method of driving was still practiced for textile machinery, owing to the more regular motion that it was considered was obtainable by the intervention of a water wheel. The power lost must, however, have been considerable for if the mechanical efficiency of the water-wheel and its gearing was 50 per cent. and that of the pumps 80 per cent, the combined efficiency could only be 40 per cent, which would be only one-half the mechanical efficiency of a direct rotative engine, so that twice the amount of coal then necessary would be consumed in doing the required work. The Museum shows the "Old Bess" pumping faithfully, only, "other days, other manners," compressed air, instead of steam, animates the old lady.



Model of a Cornish pumping engine worked by compressed air in Science Museum, South Kensington, London. This is a small example of a type largely employed in water works and also, with slight variation, in arrangement for mine drainage. It is an improved form of Watt's single acting beam pumping engine.

Beam Engine

Then there is a model, received by the Museum in 1869, of a beam engine with sun and planet motion (scale about 1:8). This represents an early double-acting rotative engine. The framing, the beam and the connecting rod are of wood. Watt's parallel motion and his sun and planet gear are fitted. To obtain a straight line motion for the air-pump rod and to avoid fouling the rods of the main parallelogram the latter is extended as a pantograph to give a guided point for attaching the rod. Tappets on this rod strike a fork keyed to an internally toothed segment gearing with teeth on the plug of a four-way cock for admission and exhaust of steam. An engine embodying this valve gear, but with cast iron, etc., beam

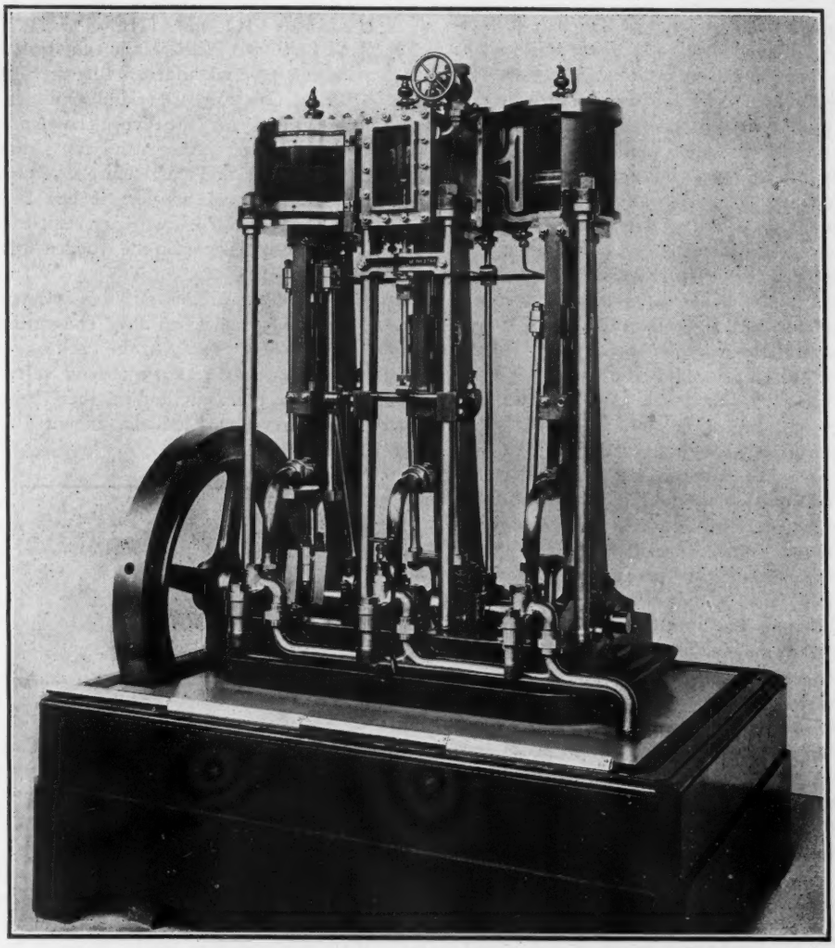
was built in 1808 at Southwark, a part of London. A circular saw arranged on a bench is driven by a band from this engine.

A model of great historical interest is that of a cabinet steam engine by James Watt. It was contributed to the Museum by A. Greg in 1858. This engine was the property of James Watt who bequeathed it to John Kennedy, of Manchester. It may be said to represent the steam engine as left by Watt. It is a small double acting beam engine with a separate jet condenser and air pump. The slide valve is of the long D form; the cylinder is steam jacketed. Watt's parallel motion is employed to guide the top of the piston rod and the air pump rod. The simple crank and connecting rod is used to secure rotative motion. The slide valve is worked by a single eccentric, and the speed of the engine is controlled by Watt's conical pendulum governor, which acts on a throttle-valve in the steam passage. The cast-iron tank, standards and beam, together with the general arrangement of the engine, hardly differed from those of similar engines of fifty years subsequently. But today compressed air operates this ancient engine model so that the engineering student may watch the operation of a Watt steam engine.

How many readers of COMPRESSED AIR MAGAZINE have ever seen a "grasshopper" engine? The museum has one in full compressed air blast. The "grasshopper" engine, so named from its peculiar motion, is intermediate between the older beam engine and the later direct acting type. It has been known also as the half-beam engine and some of our readers may recognize it under that name. In the museum model the effort of the piston rod is communicated directly to the crank and is not felt on the beam gudgeons, so that frictional loss is reduced.

The cylinder is vertical and its piston rod is connected with a cross-head, whence two connecting rods return to a double-throw crank shaft below. The cross head is fixed in one end of the beam, the other end being pivoted on two rocking links, the center of the beam is constrained by two bridles, half the length of the beam, attached to the framing. A straight line motion is thus impressed on the crosshead. The air pump is attached to the "parallel" point in an extra parallelogram obtained from the center of the beam. A plunger and a bucket-pump are driven directly from the beam. Steam is distributed by a piston valve actuated by a countershaft which is driven by an eccentric on the crank shaft. A Watt governor controls the throttle valve. The hand wheels for controlling the engine are grouped on a platform.

The exhibition would not be complete without a model of an air compressor and the one displayed was made by the Ingersoll-Sergeant Drill Company and was received by the museum in 1904. This is a model of a steam-driven "dry" air compressor, specially designed for supplying air to mining machines, and was patented in 1890. The steam cylinder is placed near one end of a box bed, and is provided with a Meyer expansion valve, by which the cut-off can be varied from 0.2 to 0.75 of the stroke. The air cylinder is placed at the other end of the bed, and the two piston rods are secured to a block to which is attached, by a central pin, a wide cross-head free to adjust itself angularly and laterally. From the ends of this cross-head, return connecting rods drive crank pins fixed to a pair of fly wheels mounted on a transverse shaft behind the steam cylinder, and on this shaft are fixed the eccentrics, which drive the valves through rocking levers; the engine is controlled by a centrifugal governor acting on a throttle valve.



A model of hydraulic pumping engine in Science Museum, South Kensington, London. It is worked throughout the hours that the Museum is open by compressed air. The model represents one of the sets of pumping engines employed by the London Hydraulic Power Co. at its central stations. The service of mains is supplied with water from the Thames, which, after filtration, is forced by the steam pumping engines into the high pressure mains. Accumulators at the station somewhat steady the demand, and also adjust the speed of the engine to the rate of consumption.

The air cylinder has water-jacketed walls and ends, while its piston is hollow and has the piston rod attached to one face, while from the other projects a hollow tail-rod forming the air inlet. In each face of the piston a circular channel is turned which communicates with the interior and is fitted with an annular valve of T section, seated on the edge of the channel; these valves are inlets, and during the stroke of the piston one remains closed by the pressure while the other is admitting air behind the piston. The delivery valves are contained in chambers in the cylinder covers, and are closed by springs; the valves are inserted from outside and the chambers are connected with the delivery by ports in the cylinder casting. The steam and air cylinders are fourteen-inch and 14.25-inch diameter respectively, and have a stroke of eighteen inches. The machine runs at 120 revolutions per min. and may be used to compress air to pressures of 50 to 100 lb. per square inch.

A model which interested me greatly was one of an air-lift pump. This was made by the museum mechanics in 1903. It demonstrates the fact, observed by Löscher in 1797, that the pressure at the base of a column of water containing air, in bubbles or otherwise, is less than with a column of water of the same height. Löscher's experiments received no practical application until 1846, when Crockford applied the principle to the raising of petroleum from the wells of Pennsylvania. In France the apparatus, under the name of an "emulseur" was used in 1886 by Gondry for raising sulphuric acid.

The apparatus consists of a vertical pipe reaching below the surface of the water to a depth of about equal to the height above the surface to which delivery is to be effected, and of a separate pipe by which air is discharged into the rising pipe at its lower end, thereby reducing the density of the column within it so that, by the external pressure, water is forced to the top and escapes with the air at the delivery end. The model in the museum shows the general arrangement

of a plant erected in 1893 at Zwickau, in Saxony, to supply a yarn-spinning mill. The water from a stream is allowed to flow into a brick chamber, in the middle of which is sunk a tube-well to give the necessary submergence for the pipes, and is raised by the air-lift into an open tank over the well; from this it flows by gravity into a service reservoir more than half a mile distant and 13.5 feet lower. The submergence is 63 feet, the lift 45 feet, the rising main 7.5 inches in diameter and the air supply pipe five inches in diameter. At a test in 1898 the discharge was 900 gallons per minute, while the volume of air required, measured at atmospheric pressure, was 2.73 times this amount; the compressor situated at the mill, delivered at 30 pound pressure above atmosphere. In the model a simple nozzle is used for the air jet, but in the actual pump a special box was found to be more efficient. In this construction of air-lift, the air-supply pipe enclosed the rising main; in some other arrangements the air pipe is carried within the rising main, but this, although convenient, entails unnecessary frictional resistance.

Other models worked by compressed air are water pressure motors, hydraulic swash-plate engines, oscillating engines, Cartwright's engine for converting the reciprocating motion of the piston into rotary motion, table engines, diagonal oscillating engines, vertical engines, double cylinder engines, double cylinder diagonal engines, horizontal steam engines, engines with "Corliss" valve gear, vertical engine with Hackworth's valve gear, rotary and disc engines, Rigg's revolving engine, steam turbines, some thirteen locomotives of different types and eras, gas and water meters, compound pumping engines, duplex pumps, feed pumps, direct-acting steam pumps, water pressure pumping engines, hydraulic pumping engines, horizontal blowing engine, ventilators, exhausters, centrifugal pumps, a ventilating fan used in the Saxon mines, steam fire engines such as are used by municipal fire departments, etc.

As I was leaving the Museum on the last day of my tours of inspection I remarked to a guard that Museums were usually dead and dried things, tombs where the mummies of genius were preserved, but that there seemed no doubt that compressed air made the South Kensington Science Museum live and breathe.

"Ah, sir," said he in his best cockney and dropping out, as cockneys sometimes do, his "with," "do you know that now we have got it, we could not bear to part our hair. Thank you, sir."

It has been noted that if attempts are made to clean an iron object covered with lead by the sandblast, the lead covering cannot be removed. It appears that the lead is forced more strongly into the depressions in the surface, and becomes tightly held there. It is suggested by the Scientific American that if the surface of a Pelton bucket be covered with lead by the Schoop process, the action of the lead will save the bucket.

PNEUMATIC ADZING TOOL

WE ILLUSTRATE here a pneumatic tool of a new type manufactured by the Turbine Air Tool Company, Cleveland, Ohio, and specially designed for the work commonly done by bridge carpenters with jack plains, adzes, draw knives and hand chisels. While we speak of the tool as new it has been thoroughly tried and its working efficiency demonstrated, especially upon the wooden ships of the war period.

The basic feature of this machine is a turbine operated by compressed air. The cutting knives are attached directly to the back of the rotating turbine, so that there are no valves, connecting rods, gears or the like, there being but the one moving part and that mounted on ball bearings.

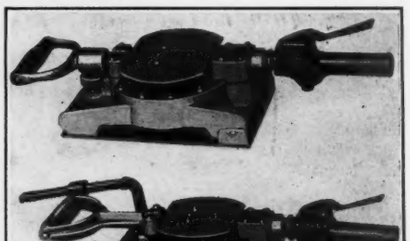


Fig. 1.—Machine for flat and for curved surfaces

The illustrations show the upper side of two of these machines which comprise aluminum frames for supporting the turbine and cutter on a shaft perpendicular to the plane of the work. There are two handles, one of which forms a part of the air inlet and is fitted with a valve to control the flow of the air. The cutter head holds two high-speed steel blades so attached that they may be released readily for sharpening. They are made adjustable to

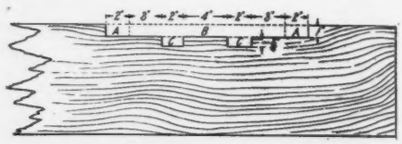


Fig. 2.—Sample of gaining work

permit them to be moved up as they are ground down. The machines are provided with a shoe on which it slides over the wood surface, the shoe being made adjustable by means of a lever or a thumb screw to control the depth of the cut. The cutters revolve at a speed varying from zero to 6,000 r.p.m. The best results are obtained with an air pressure of 100 pounds and each machine requires approximately 40 cubic feet of free air per minute.

It need not be said that these machines do the work much quicker than hand tools. In some classes of work one man with a machine has been able to do as much as ten men cutting by hand. It is also found that a man may become skilled in the use of one of these air tools in a fraction of the time it would require to learn the proper use of such tools as an adze. The manufacturers also state that the air planer does better work, particularly on rough, cross-grain wood, than can be done with the hand plane. The work is more uniform and is not so readily spoiled when passing over knots and rough spots. The drawing, Fig. 2, shows a typical cut made on a bridge tie in one minute, 55 seconds.

THERMAL EFFICIENCY OF GAS AND ELECTRIC LIGHTING

In a paper read by F. W. Goodenough before the Institute of Municipal and County Engineers the author stated that for every heat unit contained in a ton of coal brought to the electric generating station the consumer gets practically the same candlepower as does the gas consumer for each heat unit in the coal taken to the gasworks, which recalls some figures prepared by Sir Dugald Clerk.

Assuming the whole heat loss at the gasworks is debited against the principal product, coal gas, then under efficient condition of working the upright, inverted and high-pressure incandescent gas burners require respectively the use of 66, 38 and 19 B.T.U. for each candle power hour obtained by the consumer. The corresponding figures for electricity, assuming 13 per cent. thermal efficiency, at the generating station, and using filament lamps of the vacuum and gas-filled types, are 35 and 20 B.T.U. The lowest figure given is that for the flame arc lamp, which requires 9 B.T.U. to be expended at the generating station per candle-power hour.

THE MANUFACTURE OF IRON IN THE MOVIES

A 3000 ft. film has been produced at the Middletown, Ohio, plants of the American Rolling Mill Company, showing the entire process of making Armco iron, from the arrival of the ore at the blast furnace to the final inspection of the finished product. Perhaps the most interesting scene is the boiling of the molten metal in an open hearth furnace. This movie was made by the Rothacker Film Company, Chicago. It is starting out on a tour of technical schools, engineering societies and sales conventions, and it will also be carried by salesmen with suitcase projectors. The first big showing was before 10,000 spectators on a big out-door screen.

RELATIVE ECONOMY OF THE ELECTRIC DRIVE

In a paper before the Institute of Marine Engineers, Captain W. P. Durtnall gives some authentic figures showing the relative economy of the reciprocating engine, of the electric drive and of the geared drive. These figures were estimated by the operating engineers of the "Florida" and "Utah," fitted with Parsons turbines, the "Delaware," with reciprocating engines and the "New Mexico," with the electric drive. The relative steam consumption per effective horse-power hour at twelve knots was for the "Florida," 31.8; the "Utah," 28.7; the "Delaware," 21.0; the "New Mexico," 17.3. At twenty-one knots the relative figures given are: "Florida," 13.0; the "Utah," 21.0; the "Delaware," 21.0; and the "New Mexico," 16.4.

The Air Compressor in the Power Plant

PART I

By Snowden B. Redfield*

A FEW remarks as to the theory of air compression, and particularly the indicator diagram. The theoretical, single stage, no clearance, adiabatic (no cooling), no valve-loss indicator diagram is shown in Fig. 1. From *D* to *A* is the intake line corresponding to the atmospheric pressure. Adiabatic compression takes place from *A* to *B;* at *B* the discharge valves open and the air is discharged from *B* to *C* at a pressure corresponding to the air system. At *C* the piston comes to rest, the discharge valves close and the pressure in the cylinder immediately falls to *D*, when the inlet valve again opens, to repeat the cycle. In Fig. 2 is shown a theoretical diagram of a compound compressor. In this case, at *B* the air is discharged along *BC* corresponding to the intercooler pressure. The length *BC* also represents the volume occupied by the heated, compressed air which was originally represented by the length *AD*, as cold free air. When the air *BC* has passed through the intercooler it has become cooled and the volume will be represented by length *EC*. If the intercooling has been complete, so that the air coming out of the intercooler is at the same temperature as that entering the low-pressure cylinder *AD*, the point *E* will be on the isothermal curve. The isothermal curve represents the relation of volumes and pressures if the air could be kept at the same temperature by some means of cooling all during the period of compression.

The length *EC* then represents the volume of cooled air compressed to intercooler pressure which enters the high-pressure cylinder. Compression in the high-pressure cylinder then takes place along the adiabatic *EF* and discharge at line pressure takes place along *FG*.

As point *E* with complete intercooling is on the isothermal line, which started at *A*, it means that the product of the absolute pressure and volume at *E* is the same as the product of the absolute pressure and volume at *A*. Thus we can say

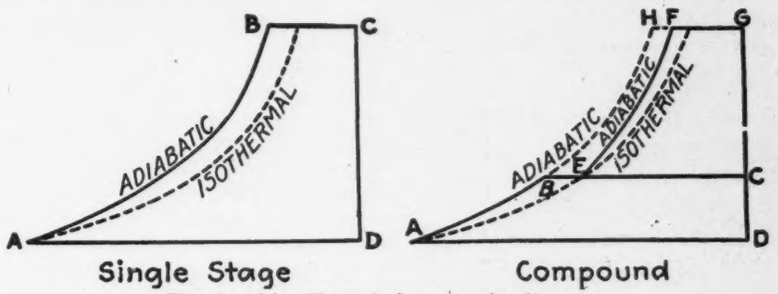
Abs. press. A × *vol AD* = *abs. press. E* × *vol. EC*, or

$$\textit{Abs. press. } E = \textit{abs. press. } A \times \frac{\textit{vol } AD}{\textit{vol } EC}$$

This means that the absolute intercooler pressure is the product of the absolute initial pressure (atmospheric) and the ratio of the cylinder volumes.

As an example, suppose that the low-pressure cylinder volume is 2.65 times the high-pressure cylinder volume, then the absolute intercooler pressure will be 14.7 × 2.65 = 38.9 lb. Subtracting 14.7 lb., the intercooler gage will read 24.2 lb.

If the compression had been single-stage, or even two-stage, *without any intercooling*, the entire diagram *AHGD*, which is the same as *ABCD* in Fig. 1, would have represented the work of compression. However, by compounding, giving a chance for intercooling, the work is represented by *ABEFGD*, the saving by intercooling being area *BHFE*.



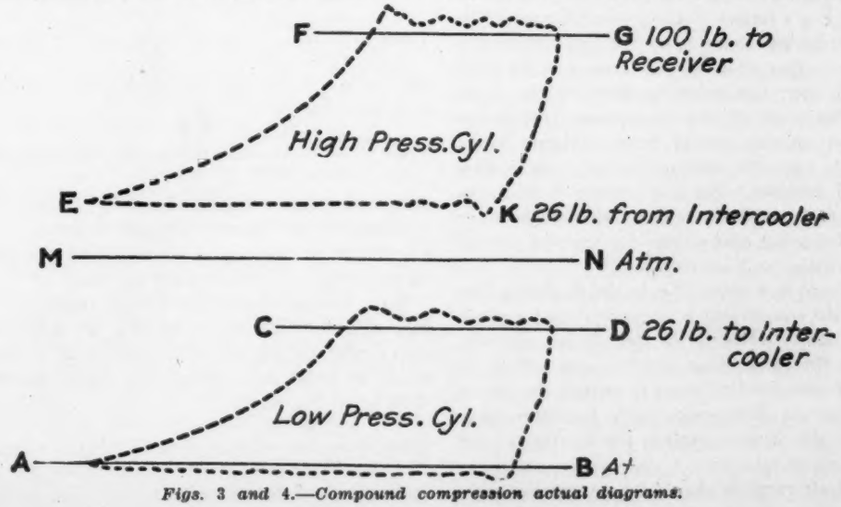
Figs. 1 and 2.—Theoretical compression diagrams

With compound compression to 100 lb. the theoretical saving is about 15 per cent of the single-stage work, and all of this saving is due to intercooling only. Excepting for the intercooling there is no saving of power by compounding, and unless a machine is properly designed the pressure losses through the valves and intercooler passages may largely offset the gain by compounding. A high-class compressor will show about 13 per cent saving in power over a single-stage machine at 100 lb. pressure.

Aside from power saving there are several other advantages due to compounding. One of these is a higher volumetric efficiency, because the amount of air trapped in the clearance spaces of the low-pressure cylinder at intercooling pressure will be less than if the pressure were of the discharge-pipe system. Another advantage of compounding is the condensation and separation of a good deal of the moisture in the air, and still another is the fact that with a compound unit the bearing pressures caused by the discharge pressure of each cylinder upon its own piston are much less than for compression in a single stage, with a machine of the same air capacity and same final discharge pressure.

In Figs. 3 and 4 are shown the actual indicator diagrams of a compound compressor of the plate-valve type. The lines *AB* and *MN* represent the atmospheric line in both cases, and *CD* and *FG* represent the discharge lines. The areas below *AB* and above *CD* and *FG* represent the excess work required to force the air through the valves, into and out of the cylinder. It is in the reduction of these excess areas that a great deal of the engineering talent is directed in valve improvements. At equal rotative and piston speeds a machine of the poppet-valve type will show much greater excess work areas on the indicator diagram than a plate-valve machine. There are other items, also, such as heating and leakage, that are of equal importance in the matter of economy. The elimination of all these bad features and the securing of durability, reliability and accessibility combine to produce a high-grade air compressor.

It is best to connect the piping the full size of the openings in the compressor. The outlets are designed in accordance with the pulsating discharge of the cylinders. Beyond the receiver the pipe lines may be smaller, because the flow will then be steady and non-pulsating,



Figs. 3 and 4.—Compound compression actual diagrams.

*Engineer-in-Charge, Engineering Department, Ingersoll-Rand Company, Easton Pennsylvania. —Abstracted from *Power*.

and the pipe sizes may be determined by the velocity to be allowed. The allowable velocity will depend upon the length of pipe and how much pressure drop is permissible. In various handbooks there are several formulas and tables for figuring pressure drop in compressed air flowing in a main. Ordinarily, for steady flow, a velocity of 2,500 ft. per min. is conservative where distances are short. Beyond the receiver this may be figured by the well-known formula,

$$Quantity = Velocity \times Area, \text{ or } Area = \frac{Quantity}{Velocity}$$

In this case the quantity is the compressed air volume, and to obtain this we must remember that the volumes are inversely proportional to the absolute pressures and directly proportional to the absolute temperatures. The absolute pressure is obtained by adding the atmospheric pressure (14.7 lb. at sea level) to the gage pressure, and the absolute temperature is obtained by adding 460 to the Fahrenheit temperature.

With air at 100 lb. gage pressure, from a compound compressor, the temperature in the first part of the discharge pipe will be about 200 deg. F., so we have:

$$Compressed\text{-}air\ volume = Free\ volume \times \frac{4.7}{100 + 14.7} \times \frac{200 + 460}{60 + 460}$$

This assumes that the initial temperature of the free air was 60 deg. F., which is a fair average, and we have

$$Compressed\ volume = \frac{Free\ volume}{6.15}$$

For a close figure we can then say the hot compressed volume of the air is one-sixth of the free-air volume when the pressure is around 100 lb.

As an example, suppose the compressor delivers 2,800 ft. of free air per minute, then the compressed air beyond the receiver will be about 466 cu. ft. per min., with air around 100 lb. gage pressure, and applying the formula,

$$Area = \frac{466}{2{,}500} = 0.186\ sq.\ ft.$$

or 26.8 sq. in., corresponding closely to a 6-in. pipe. Under these conditions the pressure drop will be a little less than ½ lb. per 100 ft. of pipe. For a longer distance 7-in. pipe would be better, giving about 1,700 feet velocity and a pressure loss of 2 lb. per 1,000 feet of pipe. Based upon the pulsating flow directly from the discharge of the compressor, the intermittent velocity would reach a figure much higher than the assumption of steady flow would indicate. For this reason it is customary for some builders to provide much larger cylinder outlet connections for the pipe joining the cylinder and air receiver.

If there is a stop valve in the discharge line from the compressor it is essential that a good-sized safety valve be located in the pipe between the compressor and the stop valve. If this is not provided there is serious danger of starting the compressor with the stop valve closed, which may result in the bursting of the compressor cylinder.

The air receiver should be as near the compressor as practicable, and there should be a separate pipe from each compressor to the receiver. The practice of connecting a battery of compressors to a long header pipe leading to a receiver outside the building is not good. Under certain conditions this produces pressure surges in the air moving down the long pipe, which materially increases the power required to drive the compressor. These surges require energy to produce and, as they serve no useful purpose, are a direct waste of power. It is better to have a receiver for at least every two compressors and each machine connected through a separate pipe of its own, the piping to the receiver being as short as possible and the full size of the compressor outlet.

There is no established rule for the size of the receiver. If the character of the work is intermittent a more generous receiver capacity is advisable. However, it is possible in most cases to store only a relatively small amount of air in a receiver with permissible pressure fluctuation. A rough rule is to provide a storage of approximately one minutes' supply of air. Thus, for a 2,800 cu. ft. compressor we would have approximately 466 cu. ft. of compressed air per minute, so a cubic content of 400 cu. ft. would be liberal receiver capacity. This would be about 66-in. in diameter by 8 ft. long. The pipe leading the air from the compressor should enter the receiver near the top and leave near the bottom to assist the separation of moisture and oil.

Intake Air Duct

Conditions of economy dictate that the compressor inlet should be connected to the outside air, instead of connecting with the engine-room cellar. It is a fact that the power to compress a cubic foot of air measured at intake conditions does not depend upon the intake temperature, but the amount of "stuff" delivered to the work (where the air is used) does depend upon this temperature.

To illustrate this, suppose that the compressor handles 1,000 cu. ft. of free air per min. Let the season be summer and engine-room cellar be at 100 deg. F., while the outside temperature is 80 deg. F. By the time the air reaches the work radiation will have cooled it to about 80 deg. If we take 1,000 cu. ft. of air from the engine room at 100 deg. F. this will amount to

$$1{,}000 \times \frac{80 + 460}{100 + 460} = 965 \text{ cu. ft. of free air at}$$

the work. If this air had come from outside it would have been

$$1{,}000 \times \frac{80 + 460}{80 + 460} = 1{,}000 \text{ cu. ft. of free air at}$$

the work. This is a gain of over 3 per cent in air quantity for the same amount of power expended, or of fuel saved for an equal amount of air, in favor of the outside air duct.

Now assume moderate winter conditions: say, outside temperature 20 deg. F., engine-room cellar 88 deg. F. The 1,000 cu. ft. of air taken in from the engine-room cellar would then be, at the work,

$$1{,}000 \times \frac{73 + 460}{88 + 460} = 970 \text{ cu. ft.; but if taken}$$

in from out of doors we have

$$1{,}000 \times \frac{73 + 460}{20 + 460} = 1{,}100 \text{ cu. ft. delivered to}$$

the work. This is a gain of 14.4 per cent in air quantity, or fuel saved by the outside air duct. Averaging summer and winter temperatures the actual saving in a mild climate can thus easily be 8 to 10 per cent of the power. This is 80 to 100 h.p. in 1,000, and is obtained by a simple air duct, which needs no attention or lubrication or upkeep when once properly installed. In a cold climate the saving would be even greater.

Mention was made that the intake duct should be properly installed. This should be emphasized, because the very heavy pulsations in an intake duct will destroy it if poorly built. A wooden duct is almost surely foredoomed unless constructed with extreme care and strength. A concrete duct, or large iron, steel or terra cotta pipe makes an excellent intake passage.

For intake ducts it is best to keep the velocities down. The lower the velocity the less the pulsations and the less the power consumed. A velocity of 1600 ft. per min. is high enough except for very short intake pipes. If the pipe or duct is 20 ft. long it would be better to go even lower, say 1,200 to 1,300 ft. Being intake, or "free" air, the velocity may be figured directly from the uncompressed volume handled. For the 2,800 cu. ft. compressor an intake duct should have an area of not less than $\frac{2{,}800}{1{,}300} \times 144 = 310$ sq. in., corresponding to 20 in. diameter if round.

Not only is slow inlet velocity an advantage in reducing air friction and consequent pressure drop and power loss, but it also tends to stop the pulsations or pressure waves which often occur. Under suitable conditions these pulsations may actually serve to increase the volumetric efficiency and air output of a compressor by the inrush of air building up a pressure in the air cylinder just at the end of the suction stroke and the beginning of the compression stroke. It is sometimes claimed that volumetric efficiencies of over 100 per cent have been obtained by this means, but this is only "apparent" and by indicator diagram measurement. Actual air quantity measurement by a nozzle will instantly show that the other losses, such as clearance re-expansion, heating of intake and leakage, tend to keep the actual air quantity appreciably less than the cylinder displacement.

Gain in volumetric efficiency by intake surge is not always to be desired, because the extra air has to be paid for in actual power and at no specially economical rate. This may even put a constant and troublesome overload on the electric equipment of a motor-driven unit.

One bad practice is to put the air-discharge pipes through the intake duct. This serves directly to defeat the gain of the cool duct, because the hot discharge pipe heats the incoming air. The writer knows of such an installation where the incoming air was heated 6 deg. F. by the presence of the discharge pipe in the intake duct. This was a direct throwing away of about 1⅛ per cent of power. Why delib-

erately throw away 11½ lb. of coal every time 1,000 lb. is shoveled into the furnace, all summer and all winter, day in and day out,.

In estimating such a heating loss a rough figure is 1 per cent loss for each 5 deg. F. intake-temperature rise.

Steam Piping and Water Piping

In installing steam-driven compressors it is of course essential that steam pipes be amply large to avoid steam pressure drop. Another essential is a steam separator at the compressor steam cylinder entrance; connect this separator drain to steam trap. Some of the most highly economical steam-driven compressors are built with piston valves, and it is well known that these valves cannot handle slugs of water as freely as the flat type. These piston valves, however, lend themselves to automatic cutoff governor control and to superheat, thus securing high economy. The steam separator is a good piece of insurance when properly drained to a trap; but it is curious to note that separators are sometimes seen without any drain pipe. What mysterious influence the operator attributes to such a device is hard to see.

Next in importance to air and steam piping comes water piping for jacket cooling and intercooling and sometimes aftercooling. The jackets do not need as much water as do the intercooler and aftercooler, as there is much less chance for absorption of heat through the jackets. The principal function of the water jackets is the preservation of the lubricant, while the intercoolers are a direct source of power saving. For every 10 deg. F. that the high-pressure inlet temperature exceeds the low-pressure intake temperature there is an increase of power of closely 1 per cent. Both intercooler and aftercooler serve to remove moisture from the air by condensation.

Jacket Water Should be Warm

For the jackets of a compound unit the total water required for the two cylinders need not usually exceed 1 to 1½ gal. per 100 cu. ft. of free air. Thus, with reasonably cold water (60 or 70 deg. F.) the 2,800 cu. ft compound compressor could get along nicely on 35 gal. per min. for the two cylinder jackets alone. For the intercooler of a high-grade compound, 100-lb. unit, it is usually safe to figure on from 2½ to 3 gal. per 100 cu. ft. of actual free air. On this basis the intercooler of the 2,800-ft. unit would require from 70 to 85 gal. per min., if the intercooler were of efficient design.

For most compressors a water pressure approximating 20 lb. per sq. in. is usually sufficient, and if possible it is best to have the outflow water piping discharge into an open funnel. By this means both the quantity and temperature may easily be observed. It is best to adjust jacket water so that as it leaves it just begins to feel warm to the hand. Any more than this is really a waste of water and any less may quickly become hot and cause excess cylinder heating and oil carbonization.

Water for intercoolers and aftercoolers is best regulated by a thermometer in the *air* leaving the cooler. There is a point beyond which even an enormous increase in water quantity will not produce appreciably better intercooling. Of course all water jackets should

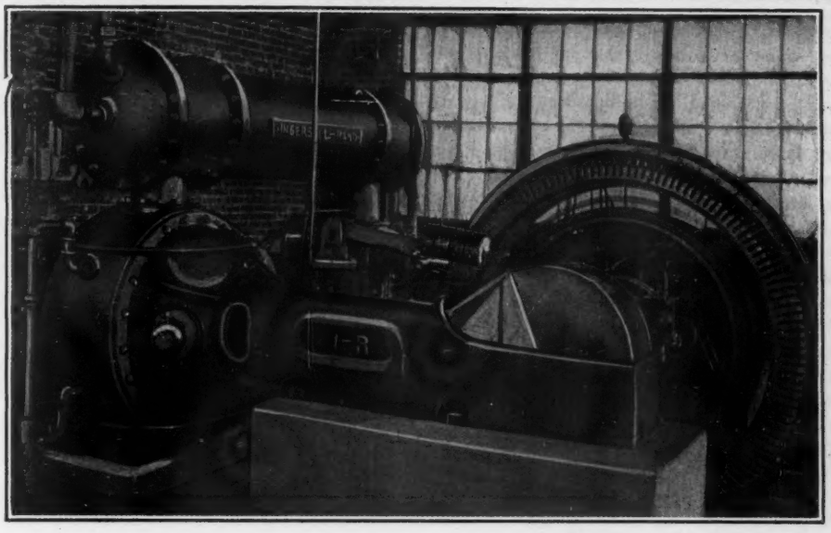


Fig. 5.—Direct connected two-stage air compressor with synchronous motor and clearance controller.

be so piped that they may be completely drained to insure against freezing in case the engine room should become cold. All first-class compressors are designed to provide for this, but the water piping should be arranged to accommodate this condition also. This also applies with equal force to intercoolers and aftercoolers.

It is a good thing to clean out the sediment and scale which may accumulate in the jackets. Large machines often have handholes in the outer jackets to assist in this cleaning, and the occasional application of scrapers and a water-hose will help on all sizes. Intercooler and aftercooler tubes need this attention occasionally. Most coolers are made so that the tube nest may be removed for inspection, repairs and cleaning.

Regulating Piping

Piping which leads air to and from the various regulating devices deserves serious consideration. In the first place, as distances may be appreciable, it is well to provide good-sized connecting piping so that a sufficiently large volume of air may be passed to operate the regulators promptly. Certainly nothing less than ⅜-in. piping should be used even for moderate distances.

There are two broad classes of regulators—those which control the speed of the compressor to suit the demand for air and those which regulate the air quantity independent of speed. In the first class come the Corliss engine-driven units and also the well-known type of "air ball governor." With these devices which take up definite positions relative to the air demand, it is usually essential to give them a little "life" or movement by connecting the pressure-regulating pipe to the discharge pipe of the compressor. By this means the pulsations of the air being discharged will serve to keep the governor parts in a condition of free movement. On the other hand, if the regulator is such that it does not operate until the air pressure reaches some definite predetermined point it is best to have the regulator as free from pulsations as possible by connecting the regulating piping to the air receiver. Unless this is done the pulsations may cause the regulator to go on and off many times due simply to pressure waves set up in the discharge air. If the connection is made to the receiver nothing will happen until a definite pressure is reached, and there should be no continued fluttering of the regulator.

Speed Control When Pressure Falls

With the governors that control the compressor speed according to the demand for air, there is usually a piston balanced by a spring or weight, or both, this piston being connected to the governor in such a way as to close or open the steam supply or alter the steam cut-off independently of the centrifugal part of the governor. In this type, then, the centrifugal action serves merely as an upper speed limit, and the compressor cannot exceed a certain speed no matter how low the air pressure may fall. Such a governor should be so adjusted that, if the air mechanism fails or the air pressure fails, the centrifugal mechanism will surely hold the machine within safe limits of speed. The air piston should move freely, but of course should not be such a loose fit as to allow leakage.

To prevent the governor piston from becoming rusted by the moisture that will come over with the air through the regulator piping a small receiver should be provided to catch the water just before it reaches the regulator. This receiver may be easily constructed of, say, a 4-in. pipe about 12-in. long and closed at each end with a pipe cap. Standing this receiver on end, the regulator piping from the air system should enter the top and also leave from the top to go to the regulator. A drain valve should be tapped into the bottom of this small receiver and care should be taken that the condensed moisture is blown out of it at least once a day.

Of course the air piston of the regulator should be properly lubricated; a lubricator is always provided by the builder.

Relief Valves Reduce No Load Power

Regulators of the constant-speed class—that is, those which act suddenly at predetermined pressures—are often of the "all on-and all-off"

type. With these regulators some form of pilot valve controlled by the air pressure acting upon a piston or diaphragm, resisted by a spring or weight, or both, admits air to the piston of the regulator proper. Thus, when the pilot valve has moved to a certain point, a port is uncovered that passes air to throw the main regulator piston. This piston moves a valve in the intake pipe, which closes off the air supply to the compressor, drawing a high vacuum and greatly reducing the horse-power of the compressor during the unloaded period.

With these regulators which close the intake it is often customary to provide some sort of automatic relief valve which at the same time opens the discharge to the atmosphere. This prevents excessively high compression of what little air leaks through the intake regulator, which would be from the vacuum in the intake to the full discharge pressure of the line. It also reduces the "no load" power, by compressing the air in the cylinder only to atmosphere instead of the full discharge pressure.

Owing to the undesirability of controlling large compressors of the electrically driven type by this sudden single step from full power to minimum power, there are some regulators built which control the machine in graduated steps. One of these as built by the Ingersoll-Rand Company operates by adding clearance pockets to the ends of the cylinders, part of the air being compressed into the pocket and part being discharged as soon as the pressure in the pocket has reached the discharged pressure. By providing four pockets for each cylinder, two at each end, each large enough to contain half the air in one end of the cylinder, it is so arranged that the unloading is in four steps: Three-quarter load, half load, quarter load and no load. With this type of regulator by the useful re-expansion of the pocketed air the reduction in cylinder power is in remarkably close relation to the reduction in air capacity, thus tending to high portent-load economy. In a compound unit the action is, of course, the same in both cylinders.

Advantages of the Step Controller

One convenient and economical feature of the four-step controller when used with electrice drive is that it may be so set that at no time will the machine operate at more than a predetermined partial load. This is convenient for repair work at night or on holiday, when only a small amount of air is required. Thus, the machine may be so locked that it cannot take more than, say, half-load, and so it is necessary to run a generator only large enough to take the smaller load. If this were not so arranged it would be necessary to run a generator of full capacity, and this would run unloaded most of the time, and consequently with poor economy.

When electric power is purchased the unit rate is sometimes based upon the maximum demand, so that this form of stop or lock may serve directly to cut the maximum demand and thus also the unit rate.

For some types of steam-driven compressors fitted with a speed governor and air-cylinder regulator it is customary to provide a steam regulator. This device is usually controlled by the same pilot valve which actuates the air-cylinder regulators, and its purpose is to slow the machine down to the minimum speed necessary to insure rotation during the unloaded period. By this reduction in speed while the air end is unloaded, less steam is consumed than if the centrifugal governor were allowed to maintain full speed.

Still another type of regulator for intermittent service with electric drive is the automatic start and stop. With this device a pilot valve or switch actuated by the air pressure starts and stops the motor automatically. Also, to relieve the motor of the heavy inrush of current at starting, special unloading devices unload the compressor before starting or after stopping. In this way the motor can start under light torque, and when at or near full speed the regulator is again automatically thrown to put full load upon the compressor, which then pumps air until again stopped by the controller.

Such an equipment as last described should be used only when very intermittent service is required, such as for fire whistles or for air charging an automatic sprinkler system. Care should be taken to keep all the electric contacts in good condition and to see that the starting unloader is in order, so as to save the motor during starting periods and also to keep down the power consumption.

Direction of Rotation

One question always of interest is: What is the best direction of rotation for a compressor? In a power-driven machine in which all the driving power is applied to the shaft, either through a wheel or by a motor mounted on the shaft, the machine should run under. Rotation in this manner with a power-driven machine tends to keep the crosshead down on the lower guide, preventing the knock that would be produced by the lifting of the crosshead if the guides and shoes became worn. Considering the outward stroke, the crankpin draws the connecting rod outward and downward, and considering the inward stroke the crankpin pushes the connecting rod inward and downward. Thus the crosshead is held down on the lower guide.

The described series of motions and forces in a power-driven machine are usually easily understood, but the conditions in, say, a steam-driven compressor of the straight line, or tandem, construction are not so easily understood.

To study this matter, consider a tandem machine with the steam cylinder between the crosshead and the air cylinder, and imagine the machine to run "over," as in most steam engines. Starting with the outward stroke, the steam pressure in the steam cylinder is at its maximum and the air pressure at its minimum. Under these circumstances the excess power goes into the flywheels, causing the machine to accelerate; the thrust of the piston rod, with the rising connecting rod, certainly tends to depress the crosshead. Somewhat beyond mid-stroke the air pressure has built up and the expanding steam pressure has decreased so that the steam and air loads may be equalized. At this instant all the steam power goes directly into the air piston. Beyond this point the air load will increase and the steam load decrease, so that the air load will far exceed the steam load.

The extra power now required to compress and discharge the air must come from the flywheels, having been stored therein at the beginning of the stroke as previously described. During this latter part of the stroke the power is coming from the crankpin, just as in the power-driven machine; but with the compressor running "over" in this case the crosshead will tend to rise.

Consideration of the inward stroke reveals the same situation: During the first part of the stroke the cross-head will be drawn down, and during the latter part of the stroke it will be thrust upward. If, now, the direction of rotation be reversed and the series of events again analyzed the same conditions will apply. For this reason a tandem steam-driven compressor may run either way so far as the raising or depressing of the crosshead is concerned. This applies equally well to cross-compound or duplex units. In the construction of certain machines, however, the builders have provided oiling devices that will function in one direction and not in the other, therefore it usually is essential to run the machine in the direction intended by the builders.

Compressor Lubrication

One of the most important items in running an air compressor is lubrication. In modern machines the running parts are usually inclosed in a crankcase and run in oil. The oil is made to circulate from the bottom of the bed over all the bearings, pins and guides and then runs back into the bottom of the bed again.

The air cylinders are sometimes lubricated by a sightfeed oiler so designed that the pulsation of the air pressure assists the feed of the oil. Also, sometimes the air cylinders are lubricated with a positively driven oil pump.

Two principles should be maintained in lubricating an air cylinder. The first is to use only the right kind of oil and the second is to use it sparingly. To be the right kind, air oil should be rather light-bodied and have a flash point above 300 deg. F. It should not carbonize under air-cylinder temperatures. These temperatures range around 260 deg. F. for compound compression to 100 lb. pressure and 360 to 375 deg. F. for single-stage to the same pressure.

How to Obtain the Right Kind of Oil for Air Cylinders

Probably the best way to secure the right oil for air cylinder is to buy oil specially made and recommended by only first-class and highly reputable oil concerns. Being in the business and having highly skilled chemists and engineers in their employ, as well as reputations to maintain, their judgment is usually a good guide. At any rate a short trial of a sample will soon demonstrate the quality of an oil for air-compressor service.

As to the second principle—to use the air cylinder oil sparingly—after a machine has been well run in three or four drops per minute are enough for a good-sized cylinder. If too much oil is used it will certainly result in excessive carbonization. Another evidence of too much oil is to see it coating the outsides of the cylinders and piping, having worked its way through the joints. This is bad practice.

One very important point is to see that the

air receiver has all the accumulated oil drained out of it every little while. If too much oil is used or the receiver is not properly drained, gases may be formed which may ignite spontaneously and cause a bad explosion. This is a point that should be scrupulously observed in order to secure safety as well as continuity of service.

It is often recommended that a solution of soft soap or laundry soap and water be fed to the cylinder at stated intervals to clean out carbon deposit. This solution may be fed through the regular air-cylinder lubricating devices. Of course, after this treatment the interior of the cylinder may rust quickly unless the soap solution is followed up with oil for some time before shutting down. Never, under any circumstances, should kerosene or gasoline be used to clean out an air-compressing cylinder. Its use may easily lead to a disastrous explosion.

CUTTING CAST IRON WITH OXYGEN

WHAT FOLLOWS is from a paper by Stuart Plumley and F. J. Napolitan before a meeting of the American Welding Society, and it relates to the happy solution of one of the puzzles which have perplexed the most up-to-date of modern metallurgists.

More than a year ago, say the writers, there were rumors heard in the industry of some genius who stated that he had cut, or could cut cast-iron. These rumors were not given much credence because it was thought that in most instances the man who believed he had cut cast-iron, had, in reality, cut something else which he thought was cast-iron.

When we succeeded in cutting cast-iron, it much disturbed our dignity in that we were obliged to reverse our former opinions and beliefs, and to take back the statement often made, that cast-iron could not be cut with the oxy-acetylene torch. Unfortunately, our experiments are by no means concluded, so that we are not free to disclose all that we would desire. Frankly, our investigation of cast-iron cutting was inspired by nothing more noble than to seek a better explanation of why cast-iron could not be cut. Most of us have expressed, at some time or other in our experience, the solemn opinion that cast-iron could not be cut, because the oxide of iron melted at a temperature higher than cast-iron itself. Not only does cast-iron burn to form an oxide, but the higher melting-point of the oxide probably assists the reaction.

While we are rather skeptical of the commercial value of a cast-iron cutting-torch, and are convinced that, financially, we will never be repaid for the expense of our experiments, yet there are undoubtedly occasions when the cutting of cast-iron would be of great value. In the ordinary scrap-yard, or in instances where the cutting process would be used as with steel, it is so easy to break cast-iron, that it would hardly be economic to use the cutting-torch. You are all aware of that application of oxygen cutting used largely in blast-furnace practice, the opening of a "frozen" tap-hole. It is impossible to reconcile this with the pet theory that cast-iron cannot be cut.

One of the usual methods for releasing a frozen tap-hole in a blast-furnace is substantially as follows: A piece of one-quarter-inch iron pipe with a brass handle, at least ten feet long, is attached to a manifold of several oxygen cylinders. Oxygen is delivered through this pipe at a pressure of approximately 100 lb. per square inch. A hole is driven with a star-drill or diamond-point, until it is about three inches deep. The metal adjacent to the hole is heated with a fuel-oil burner or by other means. The end of the iron pipe is ignited and the composite stream of molten iron slag and oxygen caused to impinge against the frozen cast-iron.

A spectator to this performance of infernal fury is readily convinced that the heat is not all due to the combustion of the wrought-iron pipe, but that the cast-iron is burning with a violence equal to that of steel. This reaction inspired some inventors to incorporate a device in an oxy-acetylene torch for cutting cast-iron that would feed a steel wire between the cutting-jet and the cast-iron piece being cut. Ignition of the wire carried a stream of molten slag on to the cast-iron and it was hoped thus to propagate the cut. In a second process, a plate of steel, of a definite and predetermined thickness, was placed on top of the cast-iron. It was hoped that the slag incidental to the oxidation of the steel would exercise some influence over the cast-iron and enable it to be cut.

Unfortunately for those responsible for the exploitation of these devices, the inventors were more concerned with converting cast-iron into iron oxide by means of the oxy-acetylene torch, than they were in constructing a practical process and a practical tool. It was next proposed to simplify the reaction by supplying an apparatus with a mixture of pulverized slag and iron powder, and in fact a number of patents were issued covering various applications of such a device. Crude and elementary as such devices were, they actually produced combustion of the cast-iron and went a long way in stimulating us in our endeavors to find a successful method.

Experimental work was continued with a torch having several tubes leading to the head so that almost any combination of gases at varied pressures might be obtained. Mr. Napolitan has evolved, from these experiments, interesting theories pertaining to the reactions which take place in cutting, together with their relation to our success in cutting cast-iron. We are presenting these theories to the members of the Society for what they may be worth. We can actually cut cast-iron, and we do it by preheating the oxygen.

Five ships, identical in design and equipment, have been built for the French Government by the Foundation Company of New Orleans. M. Le Parmentiere, a French naval architect, is reported to have originated in these vessels, a type of ship which is virtually unsinkable.

Two additional merchant mills, costing around $2,000,000 are under construction by the Steel Corporation at Gary, Ind.

ADDITIONAL JOBS FOR THE AIRPLANE PROPELLER

THE AIRPLANE propeller, having apparently not enough to do in the upper air, is now finding additional employment for both water and land service. The French Minister of Marine has been making experiments with a view to using motor driven aerial propellers for driving boats on the rivers of French colonies. In the installation shown in Fig. 1, on a canal barge, the engine developed from 20 to 25 h.p. and a speed of three miles an hour was attained. Several other experimental applications of similar propellers on boats of different types gave much better speeds.

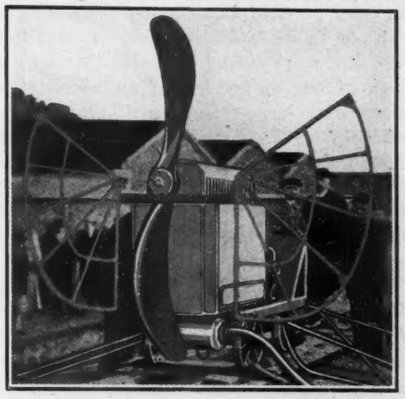


Fig. 1—Air propeller driving canal barge

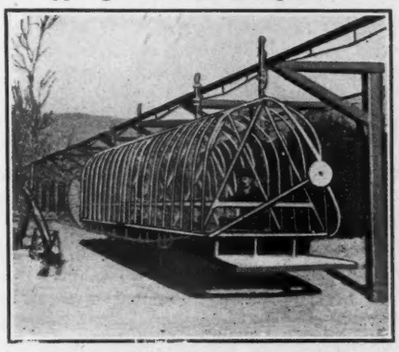


Fig. 2—Air propeller on suspended car

In the city of Burbank, Cal., a steel aluminum car, Fig. 2, running suspended from a single rail and carrying fifty-six passengers, was driven at satisfactory speed by an air propeller and gasoline engine.

GAS-WELDED TANKS

Oxy-acetyline is coming to be used quite frequently and with marked success in tank construction. The welding is perfectly satisfactory and the tanks pass all the tests. It is claimed that the tanks are less susceptible to rust than those with riveted joints, and are also much cheaper.

A tank 22 ft. in diameter by 30 ft. high, for compressed gas, has just been completed at the plant of the Liquid Carbonic Co., Birmingham, Ala. It consists of ¼-in. steel plates joined at the seams by oxyacetylene welding. After completion it withstood the proof test and was found to be gas-tight in all the seams. This, as far as known, is the largest gas-welded tank on record.

THE DEVELOPMENT OF THE PNEUMATIC GRAIN ELEVATOR*

PNEUMATIC elevators were invented in England; the first practicable machines being those of F. E. Duckham, about 1897, which were used for grain. Up to 1914, however, little development had taken place in this country, but in Germany their design had been studied and their uses largely extended so that most of the chief ports of that country were equipped with one or more floating elevators and there were also many inland examples. At the outbreak of war on account of the necessity for transporting large quantities of grain quickly and economically for the armies in the field, their use received a great impetus in this country and the Government ordered several large plants costing more than £20,000 each. The Office of Works also ordered a number of small plants for special purposes in 1918.

Notwithstanding these developments nothing of any value has been published on the action of the plants, or on the general principles of design and arrangement. From time to time there have been descriptive papers; but tests and design data seem to have been jealously reserved by the constructors, and the writer believes that for the most part the designs have been empirical, otherwise many obvious mistakes would have been avoided.

The attention of the author was first drawn to this subject about 1913 when having made himself familiar with Continental practice he began a research which was interrupted by the war in 1915. Subsequently he approached, in 1918, the newly-formed Department of Scientific and Industrial Research which gave him a grant towards the expenses of a research to be carried out in connection with a plant provided by Messrs. Thomas Robinson and Sons, of Rochdale. The research was proceeded with, at Manchester University with the permission of Sir J. E. Petavel, and the work was largely carried out by Mr. A. Priestley, M. Sc.

The experiments were confined to wheat, this being a material frequently elevated by pneumatic means, and having fairly constant dimensions. The power required to elevate granular material at a given rate can be expressed in terms of the difference of pressure across the conveying pipe and the quantity of air per second moved under this pressure difference. The part of this which appears as useful power can be expressed in terms of the weight of material lifted per second and the height to which it is raised. The ratio of these two powers gives the efficiency of the plant. It is evidently easy to determine this experimentally, but there are great difficulties in formulating a satisfactory theory connecting the large number of variables in the appropriate equations. With a given current of air it is necessary to determine and connect reliable expressions for the following quantities:—

(1) The force, acceleration, and velocity with which the material is moved in air of varying density.

(2) The retarding forces on the material.

(3) The retarding forces on the air.

*From a paper by Professor William Cramp, D.Sc., before section G of the British Association at Cardiff, Aug. 27, 1920.

In order to arrive at the force acting on the material a number of experiments were made with special apparatus, and from these a factor was arrived at which, when multiplied by the square of the velocity of the air relative to the grain gave the force on each berry within certain limits. Using this factor a series of velocity distance curves could be deduced from the appropriate velocity equation assuming the density of the air to be constant. This velocity was then checked by measurements made on the complete plant, but the results were not found to be altogether consistent, the calculated value of the mean velocity being usually higher than the experimental value, due no doubt to friction between the grain and the pipe.

No satisfactory experimental means of separating this friction from other phenomena were available and ultimately it was necessary, in the absence of a complete theory of the motion of the particles, to deduce the value of this force from repeated comparisons between theory and experiment, until a satisfactory expression, having a rational basis was arrived at. The other forces acting in the system, viz., the friction between the air and the pipe, and that between the grain and the air were similarly dealt with until all the factors required for connecting the forces with the change of momentum had been accounted for and a general equation could be written down.

The final equation embodying the results of these experiments takes the following form:

$$p_0 - p = \frac{L}{F}\left\{\left(2{\cdot}1 + \frac{A}{\sqrt{L}}\,8\right)V_f + B\frac{S}{V}\right\} + C\frac{V_a^2 S}{d} + D\,V_a^2.$$

Where $p_0 - p$ = Vacuum in cms. of mercury.
S = Length of pipe in metres.
F = Area of pipe in square cms.
A = Diameter of pipe in cms.
L = Grain lifted. Tons per hour.
V_f = Grain velocity at the top of the pipe in metres per second.
V_a = Air velocity at the top of the pipe in metres per second.

and
$$V_f = \frac{V_a - \sqrt{\frac{E}{\sqrt{L}}}(V_a^2 - F) + F}{1 - \frac{E}{\sqrt{L}}}$$

The constants A, B, C, D, E, and F depend chiefly upon the type of material which is being elevated and were all determined for the wheat used and the results were then checked against the actual figures obtained from experiments upon the complete plant. The results of this comparison are given in the table in next column.

In the course of the experiments the influence of the form of nozzle used became prominent. Tests were made therefore on a number of nozzles to ascertain the manner in which they influenced the behaviour of the elevator. It was found that for each type of nozzle there was a certain constant representing the number of tons drawn into the nozzle per hour per square centimetre of nozzle area per metre per second of air velocity at the nozzle calculated on the full nozzle area. This has an important bearing on the amount that a given plant can lift per hour. Since mechanical elevators can be designed to work with an efficiency of 75 per cent., it is very important that the maximum theoretical efficiency of a pneumatic elevator should be known and compared with its rival. If we regard the velocity energy of the grain as a loss, which is usually the case, then for various shapes of pipe giving different accelerations the theoretical efficiency cannot exceed 40 per cent. In practice no pneumatic elevator approaches this efficiency and yet they are used because of their labor saving qualities and freedom from dust. From the equations and experimental work it would seem that there is no reason why the efficiency of commercial plant should not easily be doubled, and if the results of this research are put into operation it seems certain that an improvement of this order will be effected.

Tons per hour lifted.	Va. Metres per second.	Vacuum calculated cms. of mercury.	Vacuum measured cms. of mercury.
1.39	20 30 41	7.3 10.5 14.8	7.2 10.8 13.5
2.38	19 33	10.4 16.1	11.2 16.8
3.72	19 29 37	14.6 19.6 24.6	15.3 19.6 23.8
4.85	18 26 34	17.7 21.9 27.4	18 22.3 26.4
6.3	27	27.4	27.5

Table of Calculated and Actual Vacua for a Pipe 9 M. Long and 4.8 Cm. Diameter

SHOVELED-UP HIGHWAY FOR ITSELF TO CROSS A RIVER

An interesting piece of work was recently accomplished by a Bucyrus electric drag line excavator at Englewood, Ohio, U. S. A. It was necessary for this excavator to cross the Stillwater River at a point where it is 250 ft. wide and 6 ft. deep. The crossing was accomplished by the excavator first building an embankment out into the stream. When this had extended some distance out the excavator moved on to it till it approached the end. It then cut into the embankment behind it and transferred this material to the front, and continued taking, so to speak, its island with it, till a crossing 400 ft. in length had been accomplished. The embankment made was 30 ft. wide at the top and 60 ft. wide at the base, and was composed of gravel and small boulders. The job occupied four days of eight 10-hour shifts.

Upton, near Peterboro, one of the smallest parishes in England, numbering only fourteen houses, possesses a tombstone of black marble which becomes damp in patches whenever rain is about to fall. It is regarded in the village as an infallible barometer, which is hardly correct as its indications tell only of humidity and relative temperatures and not of atmospheric pressures at all.

THE DANGER OF THE EMPTY OIL TANK

THE FOLLOWING interesting discussion comes to us as an enditorial note in a recent issue of *The Engineer*, London. It calls attention to and quite lucidly explains a frequent source of danger not generally recognized or guarded by proper precautions.

The explosion of an oil barge at Millwall recently, when several men lost their lives, coupled with the recent burning of another Thames oil barge, attracted a considerable amount of attention on account of its bearing upon the growing use of oil as fuel on board merchant ships. The barge belonged to the Anglo-American Oil Company and had been sent up the river for repairs, but had been previously emptied of oil. The cause of the explosion is assumed to have been the accidental ignition of an explosive mixture of gas which had been left in the tank after the oil had been pumped out. The explosion was so severe that it caused considerable damage to buildings some distance from the wharf. The Port of London Authority has very stringent regulations concerning the passage of vessels which are, or have been, carrying oil up and down the river, but one rule it seems had not been complied with in the case under review. The whole subject is one worthy of very serious consideration, as the transfer of oil barges must to some extent be associated with its extended use as fuel by the mercantile marine. It has not yet been disclosed what class of oil had been carried by the wrecked barge, but there is, unfortunately, an idea in the minds of many that heavy fuel oil tanks carry no risk of fire or explosion. As a matter of fact it is an extremely difficult operation entirely to rid a tank of all traces of oil or gas after it has once been used. The usual procedure is to fill the tank with sea water and let it flood out over the decks to wash out the oil; but there are almost always air pockets at the top of tanks which cannot be reached in this way, while the landings of plates and angles form lodgments for traces of oil. The tanks are therefore blown out with steam and finally men are sent down to swab out the corners. Structural convenience presumably necessitates the existence of awkward places, which are very difficult to free from all trace of oil, and while there is any oil in a tank there is always a probability that gas may be generated and an explosive mixture produced.

A British scientist advances the lugubrious prediction that famine will menace the world in the year 1924. If the retail profiteers in America are permitted, in the interim, by the national administration elected in November, to keep on extorting fabulous prices for food, those of us that manage to withstand stomachic privations until 1924 will be quite accustomed to starvation. The fly in this comforting ointment is, however, that like the celebrated horse that got accustomed finally to its diet of sawdust, we may pass out of this earthly picture about that time.

AUTOMATIC BRAINS WANTED

By RUFUS T. STROHM

From *Power*

There are scads of strange devices in our power plant today,
Made to put an end to trouble and to keep the jinx away,
While a lot of them are fashioned with the pleasing end in view
Of avoiding heavy labor that would fall to me and you;
But although they're almost human in the way they do their share,
They require close inspection and they need continued care;
So some accidents will happen and some trials will remain,
For we haven't found the fellow with an automatic brain.

You can use a warning whistle of the kind that starts to blow
When the water in the boiler gets too high or falls too low,
But your hair will turn to silver while you wait to hear it wail,
If the water-column piping isn't free from sludge and scale;
And unless the water tender is alive and on the jump,
It will never halt disaster though it blare like Gabriel's trump;
For a boiler can't forevermore withstand an overstrain,
And we haven't found the fellow with an automatic brain.

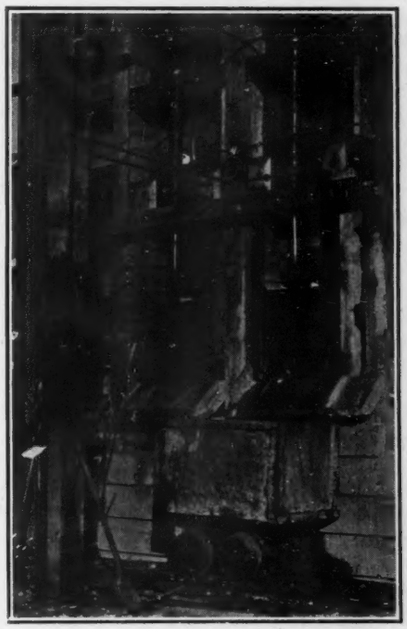
You may furnish every engine with a form of safety stop,
With the object of protecting all the workers in the shop,
But you've got to clean and oil it, or its joints will rust and grip,
And you'll find it out of order when you're praying it will trip.
So, you see the risks you're running and the chances that you take
If the chief and his assistants aren't keen and wide awake;
Troubles thrive where men are careless, foolish, ignorant or vain,
Since we haven't found the fellow with an automatic brain.

Thus with stokers, lubricators, non-return valves and the like—
They are mighty clever helpers, but they're sure to go on strike
If, when you have made them part of your equipment, you proceed
To forget you ever bought them and ignore the care they need.
You will find that they'll protect you, and your drudgery will shrink,
But they're only brass and iron, and they weren't made to think;
So you needn't look for absolute security to reign
Till the race brings forth the fellow with an automatic brain.

BUNKER GATES OPERATED BY COMPRESSED AIR

THE ACCOMPANYING photos show the bunker gates on the Big Creek Shaft of the Hetch Hetchy power and water project which are operated by compressed air.

There are two air cylinders each having a piston which extends downward and is attached to the top of the bunker gate. Compressed air pipes are connected to the bottom and top of the cylinders. By means of the valves the compressed air can be directed into either the bottom or top of the cylinders, thereby raising or lowering the bunker gates. The compressed air pipe extends up the post to a height of about eight feet. Here there is a branch which connects to the pipes which extend upward on either side of the post, one set of pipes for each of the two cylinders. An overhead electric light with a reflector, provides ample light for operating the bunker gates at night.



Big creek shaft bunkers showing compressed air gates

MEASURING AIR VELOCITIES

At a meeting of the British Engineers' Association, Prof. Macgregor-Morris described an instrument which gives direct readings of the speed of air currents. It is based on a simple electrical principle. When an electric current passes through a wire the wire becomes heated and its electrical resistance changes accordingly. By using two identical wires, both carrying the same current, and by protecting one from the cooling effect of wind, the difference of electrical resistance between the protected wire and the unprotected wire affords a measure of the cooling effect, and thus of the speed, of the wind. On these lines the inventor has devised a portable apparatus which reads directly in miles per hour with remarkable accuracy. The chief use intended for this apparatus is for measuring the ventilation of coal mines, but it has many other applications.

ROADMASTERS HOLD ANNUAL CONVENTION AT ST. LOUIS

THE 38th ANNUAL Convention of the Roadmasters and Maintenance of Way Association was held in the latter part of September in St. Louis, and proved to be one of the most successful conventions ever held by that organization. The attendance was remarkably good, there being over 700 roadmasters and other railway men present, representing every part of the United States and Canada.

The convention was called to order on the morning of September 21 by the president of the Association Mr. J. W. Powers. Colonel F. G. Jonah, chief engineer of the St. Louis-San Francisco, and president of the St. Louis Railway Club, welcomed the Association to St. Louis. In the evening the members of the St. Louis Railway Club were the guests of the Roadmasters Association, at which time Colonel Jonah read a paper on "Method of Increasing the Efficiency of Maintenance of Way Forces," and this was followed by a moving picture entitled "The Americanization of Tony" which was presented by the Pennsylvania Railroad, and intended to educate railroad employees in efficient and safe methods of working.

President Powers in his opening address commented on the importance of associations and conventions. He stated that we are living in a day when the community of workers is being constantly and aggressively forwarded and that we are making collections of knowledge not on an isolated plan but on one of broad interests. Continuing he said: "No association has a more important field for studying the exchange of ideas than the Roadmasters Association because of the many important problems now confronting the maintenance of way department during the period of reconstruction and that there is a demand for all the constructive work and knowledge that it is possible to secure.

During the convention reports were made on the "Economic Weights of Rails;" "The Maintenance of Track Joints," by R. H. Howard, chief engineer of Maintenance of Way, Wabash, St. Louis, Mo. "Equation of Track Values;" "Increasing the Efficiency of Track Labor;" "The Use of Treated Ties;" "Supervision;" "Where are our Ties Coming From?" by Hermann Bonschrenk, consulting timber engineer, St. Louis, Mo., "Construction of Street Railway and Farm Crossings;" and "Welding."

One of the very pleasant features of the convention was the dinner given to 533 roadmasters and their families on the evening of September 22 in the Grand Ball room of the Statler Hotel. Mr. Wm. H. Armstrong, president of the Track Supply Association acted as toastmaster. In his address which was enthusiastically received, Mr. Armstrong struck a realistic keynote when he stated that there was no question of greater importance than that of morale among the maintenance of way forces. Mr. Armstrong spoke as follows:

"You Roadmasters are charged with the duty of producing results. Efficient and satisfactory results can only be produced by an organization whose morale and disposition to efficiency is on a hundred percent basis. Therefore, a grave responsibility rests upon you men in re-establishing that esprit de corps and morale among your section foremen and laboring forces which spells success, not only for your own railroad, but for the transportation system of the country, which is a vital part of our country's prosperity.

"You are confronted today with an entirely different problem than existed at our last meeting. The railroads have passed out from under government control. We are now emerging from the effects of a war period which brought with it an appalling spirit of unrest among our laboring forces. Carelessness, indifference, radicalism and strikes entirely outside of the scope of the law have taken place as a result of this restlessness. It is not only your duty and obligation, but should be your ambition and pride to overcome the effects of all these disturbances, and re-establish that old spirit of harmony and helpfulness between the Railroad and its employes that existed during the pre-war period, and which meant so much for the advancement and prosperity of each individual.

"As the years roll on, conservative labor will see more and more the advantages of private control of the railroad systems. You can help to bring about quickly this realization. If private control is to be made a success, and the railroads can only be successful under that form of operation it will be through the loyal support of its army of employees.

"I am glad to find that almost to a man the same zealousness, loyalty and desire to maintain one hundred percent efficiency prevails among the Roadmasters and Supervisors that prevailed prior to this war period of unrest. I have the greatest admiration and respect for you in this attitude of unwavering and unflinching loyalty to your employers, and I know likewise that you enjoy the admiration, respect and support of the railroad officials by whom you are employed, and that as time rolls on and you make yourselves more necessary to your employers, it will result in success and advancement.

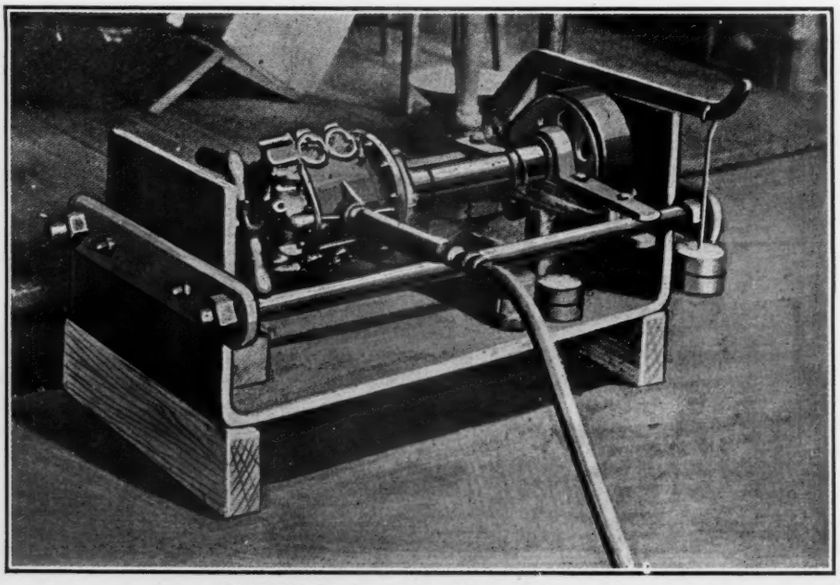
"Gentlemen, this is your golden opportunity to show the best that is in you and I am sure that bread cast upon the waters will return to you."

The toastmaster then introduced the two invited speakers of the evening Mr. C. E. Johnston, general manager of the Kansas City Southern, Kansas City, Mo., and Colonel F. W. Green, vice president of the St. Louis, Southwestern, St. Louis, Mo. Mr. Johnston chose for his topic "The Existing Labor Problem" and discussed its scarcity and inefficiency. He recounted the history of labor during the last five years and the conditions which have led up to the present situation. One of the most serious problems Mr. Johnston noted was the fact that the character of the men was such that very few of them are suitable for promotion to foremen. He urged the roadmasters to interest themselves in the morale of their men, to obtain a greater personal contact with them and to learn their problems.

Colonel Green in his speech referred to the old time roadmaster and his resourcefulness and perseverance. He agreed with Mr. Johnston's views in regard to the labor situation and also advised a greater personal contact with the foreman as a means of obtaining better results.

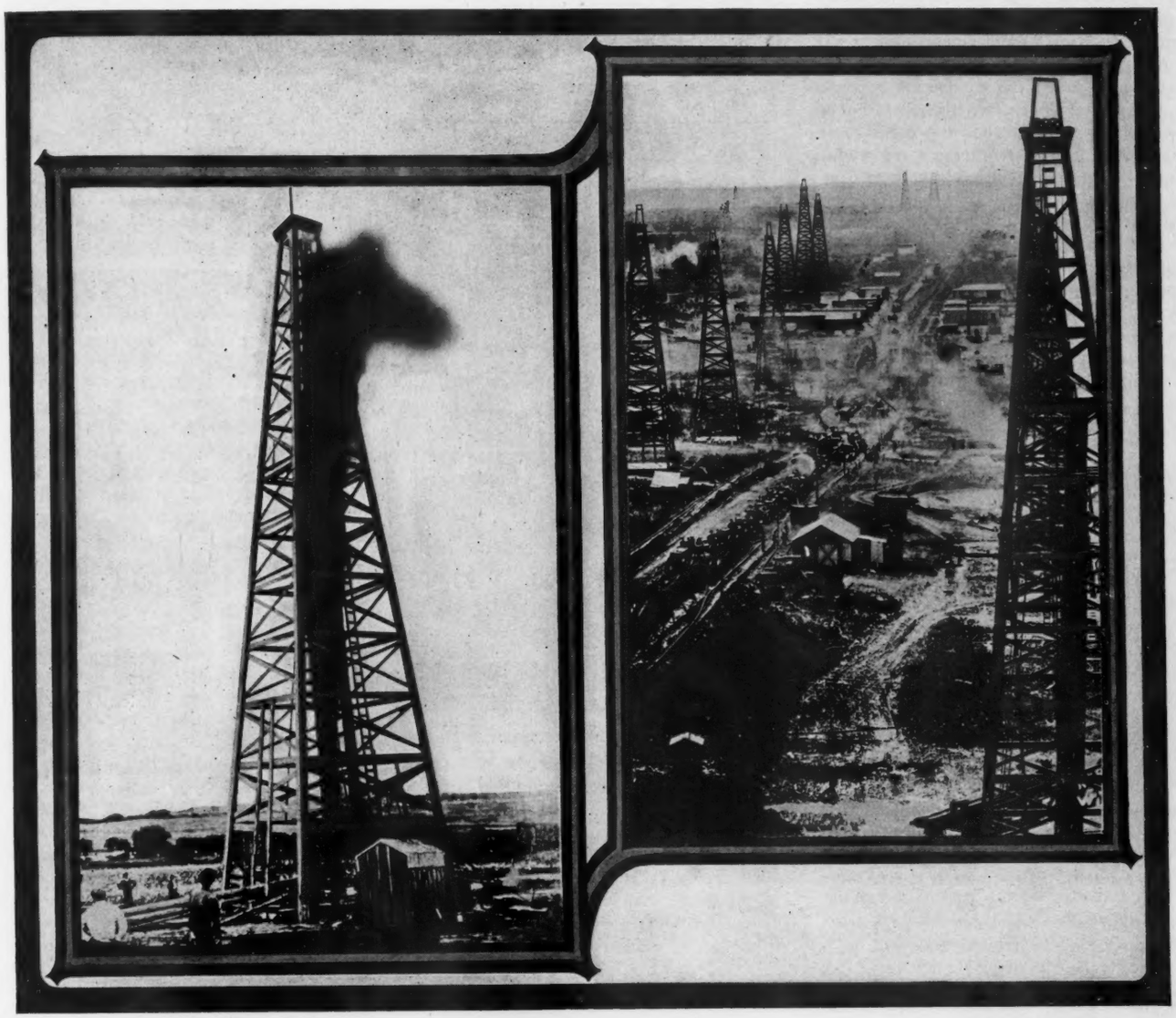
PRONY BRAKE FOR TESTING AIR MOTORS

At the Norfolk and Western Railroad shops it was found that for some reason repaired air drills did not always develop the power that they did when new, and accordingly a prony brake was rigged up for the purpose of testing them. A view of the apparatus, here reproduced from *Ry. and Loco. Engineering,* requires no explanation. The drills are attached to the brake when new and a run is made to determine the power they can develop when running at speed under standard air pressure. After they have been repaired they are tested again, and if they fail to come up to their own record they are overhauled and then tried again until satisfactory.



Prony brake for testing air motors.

Compressed Air Increases Production of Petroleum—World's Most Wonderful and Useful Fuel



PRODUCTION of petroleum at the present time is a matter of the utmost importance to the entire world. The most inventive and scientific minds of all countries have been investigating the situation from all angles looking forward to a solution. The entire automotive industry which is growing by leaps and bounds is entirely dependent upon this most wonderful fuel and the oil-burning ship a recent development acquired by the necessity of an increased cruising radius must have supplies of various products of petroleum. Our photos are typical of a famous American oil field. On the left is shown the "Texas Chief" gushing all over the landscape. The oil is driven upward to the surface many feet in the air because of the pressure exerted by the natural gas that is present in the earth. When this gas has escaped and the pressure is reduced, compressed air can be used to replace it and thus regain the normal production. In this issue is discussed editorially the importance of this method. On the right is shown the road from Burkburnett to Newtown, Texas, once a lonely country trail that is now filled with an almost endless chain of auto trucks and drays filled with supplies for this wonderful oil region. Forests of derricks line the roadway.

The petroleum resources of the United States are estimated to be only sufficient for about 20 years by geologists of the U. S. Bureau of Mines. This situation has been a matter of serious concern to the government as unless American capital is successful in increasing its foreign petroleum deposits it will prove to be a considerable detriment to American industry.

West Virginia is the largest producer of natural gas. One company in that state has had in operation more than 3,400 gas wells. Its pipe lines, varying in size up to 20-in. diameter, aggregate 3,300 miles; there are 37 compressing stations with a total of greater than 50,000-hp. Some of the gas is compressed to a pressure of 250-lb. per sq. in.

THE ARGUMENT FOR GAS IN MODERN WARFARE

Gen. A. A. Fries is of the opinion that efforts to rule out the use of gases for military purposes by international treaties are not likely to be successful. Gas warfare gives a very great advantage to the intellectual and more highly developed peoples, he says. As a nation develops intellectually there is a tendency to lose in brawn. The development of chemical warfare has put in the hands of the more highly developed nations a weapon which would render them absolutely safe from successful attack from any invader who might happen to have more brawn. Gases form the ideal weapon of the highly civilized man. When gunpowder was introduced in warfare similar protests were made against its use. It is also pointed out that, since the gases used in chemical warfare are also widely used in our industries, there certainly could be no agreement to stop their manufacture or not to have the means of production handy if war should break out.

COMPRESSED AIR PRACTICE IN ASSOCIATED OIL SHOPS

THE Associated Oil Company maintains extensive shops at San Francisco for the repair of the large fleet of automobiles, trucks and other equipment.

In the main shop there are two air compressors which provide air for the operation of the air drills, air hammers and other pneumatic tools. These compressors are shown in figure 1 and are supported at a point overhead, which saves room. They are operated by an electric motor, also placed overhead. One of the compressors is held in reserve, and is used in emergency or in case the other compressor should need overhauling.

Air is maintained at a pressure ranging from 140 to 160 lb. In order to handle this pressure, a section of an oil-well casing is used as an air tank. This is set on end in one corner of the building and therefore does not take up valuable room. This casing can be seen at the extreme left in Fig. 1. The ends of the casing have been welded.

Air connections are provided at all doors, and long lines of hose are provided for operating air driven machines, in making repairs to motor trucks parked in the yard. The air hose is laid along the ground, and planks placed on each side of the hose permitting autos to be driven over the hose without injury.

Figure 2 shows an air compressor installed in the electrical department. The compressor, electric motor, tank and automatic cut off, are one unit. This equipment is supported on a box in one corner of the room and takes up but little space.

The electric motor is mounted on the tank by metal bands at a height of about four feet. The compressor is attached to the top of the air tank by metal bands, and is driven by a belt.

Air is used for testing inner tubes for leaks, and a special connection is provided at a bench for this purpose. Air is also used in spraying distillate on electrical parts for cleaning them. The distillate is carried in a square tank, supported on one of the walls of the room, and the spray device is connected with the tank by a hose.

By opening a valve on the spraying device, the air pressure forces the distillate at considerable pressure, and the combined action of the distillate and air quickly removes dirt and grease from the parts on which the spray is directed.

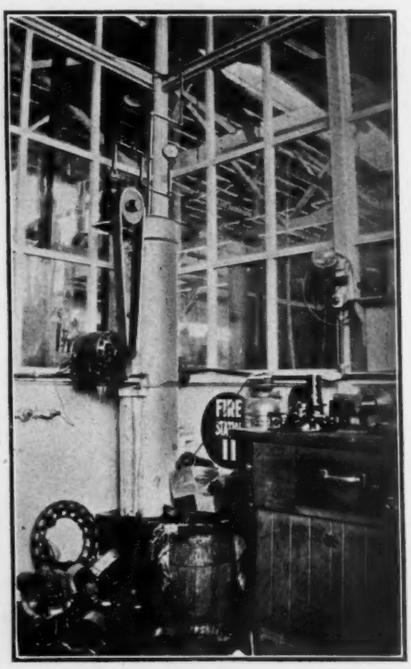


Fig. 2—The compressed air equipment in the electrical department.

Compressed air is also used for testing spark plugs under pressure. This is a special testing device designed by the superintendent of the shop, and is capable of testing six spark plugs under pressure at one time. A gage is also provided for ascertaining the pressure under which the plugs are tested.

Compressed air is also used in the paint and varnish department of the shops, and a compressor is installed in the paint shop for this purpose.

The shop also makes all repairs on the air compressors that are installed in the service stations maintained by the company. A number of new compressors are carried at the plant, ready for installation in any new service station that might be built.

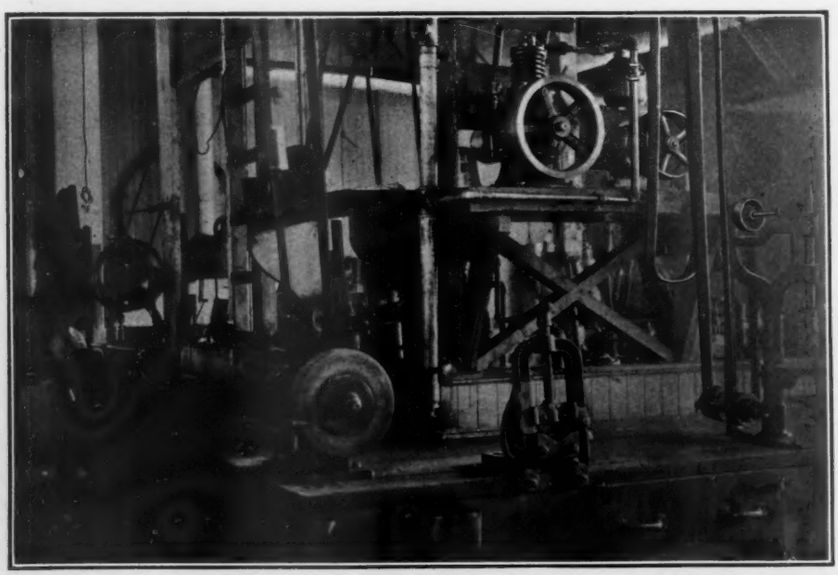


Fig. 1—The two air compressors are shown just above the drill press at the right. A short distance to the left is the electric motor and on extreme left is the section of casing that serves as an air tank.

FOR BEST RESULTS FROM HAMMER DRILLS

*By HOWARD R. DRULLARD**

BEST results from hammer-drills may be obtained by giving close attention to two factors in drill maintenance. They are of equal importance; one is lubrication, and the other is care of the shank.

Lubrication

With the exception of stoping-drills, most modern rock-drills require both oil and grease. The oil-ports are in the lubricator, on or behind the hammer-cylinder; the grease-port for the lubrication of the chuck-sleeve and rotating mechanism is on the chuck-end. Ordinary machine-oil is not adapted to rock-drills; a heavier more gelatinous oil such as castor machine-oil or liquid grease should be used.

The lubricators should be filled once for every twelve or fourteen feet of hole drilled. Grease-guns should be used to fill the port in the chuck-end once a shift; a medium grease is well adapted to this purpose. Hard grease must not be put into the lubricator, as it will not flow through that part. Contrary to the popular belief, oiling a machine once or twice a shift does not provide sufficient lubrication; the drills should be oiled once for every twelve or fourteen feet of hole drilled.

The rotating handle of a stoping-drill is an oil-reservoir and is provided with a port for oiling. The rotating handle is packed with wicking, or similar material, which causes the oil to feed slowly from the handle to the other parts of the machine. Stoping-drills require oil at least twice a shift; lighter oils than castor, such as Arctic Ammonia, may be used.

Drills used in shaft-sinking can be oiled satisfactorily by placing a good-sized drop-sight lubricator on the station above and connecting it with the air-line supplying the sinking-drills. If this lubricator is properly filled and adjusted, a uniform oiling of the sinking-machines will be effected without the necessity of oiling the drills individually. The grease end should be filled at the station or on the surface before each drilling-period. The shift-boss should see that the machines are greased and also that the lubricators at the station function properly. The life of the air-drill hose is somewhat shortened by this method, as oil attacks the inner tube; but as some oil is always present in the compressed air, this is not a serious objection to the method.

*Abstract of paper at Lake Superior meeting of Am. Inst. of Mining and Metallurgical Engineers, Aug., 1920.

When operating wet drills, the water-valve should always be closed before the air is shut off from the machine so that any water leaking from the water-tube will be exhausted from the machine. After drilling is finished, the machines should not be carelessly thrown aside, but should be carried well back from the face and placed in a clean dry place. Many experienced drill-runners stand the drifting and sinking-machines chuck-end up and pour a liberal quantity of oil into the chuck-end. This prevents rusting if there is moisture in the machine; also, the oil finds it way into the small parts, such as the rotating mechanism.

Stoping-drills are often stood in the opposite manner; that is, with the chuck-end down. Oil is then poured around the air-feed piston, often called the "feed bar." The oil flows down the piston into the air-feed cylinder, keeps the cup leathers soft and pilable and, if the leathers are somewhat worn, passes on into the other parts of the drill.

When machines have been in service for some time without being repaired, they should be sent to the surface to be cleaned and oiled. If this is not practicable, good results can be obtained by pouring five or six ounces of coal oil into the air hose, connecting it to the machine, and then running the drill for a minute or two. This will usually clean a drill quite thoroughly, but care must be taken to keep all lights away from the face for a few moments for, as the oil breaks up into very fine particles as it is exhausted from the machine, it forms an explosive mixture, which has been known to flash and burn the hands and face of the drill-runners. After the machine has been thus cleaned, the lubricators filled, and several ounces of oil poured in the drill hose, the machine will be found to operate much more freely than before cleaning.

Drill Shanks

The method of forming drill-shanks on a standard drill-sharpener is simple and quite generally understood. The shanks, however, must be accurately made and maintained at the dimensions specified for the particular steel. A variance of one-fourth inch in length will often reduce the drilling speed of the machine 25 per cent. Close attention must also be paid to the shape and location of the hole made to accommodate the water-tube. To avoid excessvie breakage of water-tubes, this hole must be five-sixteenth inch diameter and punched to the depth of at least three inches. It must be in the center of the steel and, after punching, should be counter-punched slightly to prevent a sharp edge forming that will cut off the water-tube. The shank, of course, should present a smooth striking face.

The shank, when properly formed, is hardened. Sometimes this process is not thoroughly understood. The operation is simple, involves no delicate judgment of temperatures or high mechanical skill, can be learned by any intelligent blacksmith in a few moments, and makes a shank that will not batter, break, or damage the piston hammers of the rock-drills.

The proper treatment of the shank begins in the forging. The steel must not be overheated; that is, it must not approach a white heat. The work of forming the shank should begin as soon as the steel attains a bright red heat. The steel must not be allowed to "soak" in the fire, as this causes scaling; an unduly high air pressure in blowing the forge will also cause the steel to scale, and a scaled shank will not respond properly to the hardening process. After forming, the shanks should be annealed by being cooled gradually; preferably they should be covered with lime or ashes and allowed to cool.

Either fish or linseed oil is satisfactory for hardening, although other light oils are at times used. The quantity required is proportionate to the number of shanks to be hardened at one time; five gallons will suffice for the hardening of three or four shanks, but if considerable steel is being worked, 45 or 50 gallons are advisable. A rectangular tank in which the steel can be stood on end conveniently is generally used. A heavy screen should be placed four or five inches from the bottom in order to hold the steel above any water or dirt that may collect in the bottom of the tank. The oil must be kept free from any foreign matter, particularly water, for water collecting below the oil will over-harden any hot steel that comes into contact with it.

The shank should be heated to a cherry-red at the striking end, with the heat graduated to a dull red just beyond the collars, or lugs; or in the case of the shankless stoping steel, to a point about four inches from the end. The shank is then plunged into the oil and allowed to cool thoroughly; the operation is then finished except for testing.

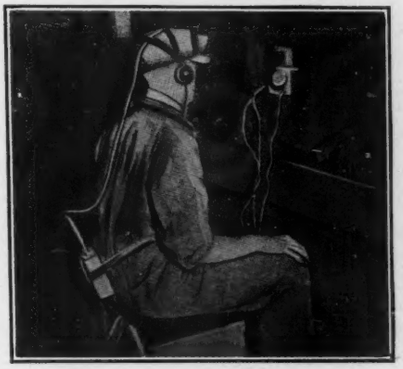
One thing must be borne in mind; each and every shank must be so hardened that it can be readily cut with a file. The shanks must be softer than the piston hammers or damage to both will result. It is obvious that if two pieces of steel of approximately the same hardness are brought violently together, one or both will be damaged. If any piece cannot be readily cut with a file, it should be rejected and re-hardened and the oil tested for water. Care must be taken that too many shanks are not treated at one time, and the oil overheated; if the oil becomes hot, soft shanks will result. The often-used draw-temper water-method requires an extremely fine knowledge of color values, is seldom accurate, and is much slower than the oil method, therefore it should not be used. If the shanks are properly hardened, any well-made piston-hammer will take care of itself.

The contract for the construction of the pipe line for the transport of oil between Havre and Paris has been awarded by the Compaignie Française de Transports des Mazouts et Petroles to the New York firm of James Stewart and Company. The contract with the Stewart Company provides for the installation of the pipe for the transport of petroleum and the construction of pumping stations and storing bases. The pipe will be 201 kiloms. (125 miles) long, with a diameter of 10-in. It will be constructed of steel. There will be six pumping stations, and at each extremity of the line a storing base with six sheet iron reservoirs each of 10,000 tons capacity.

THE GEOPHONE

THE geophone is one of the many devices developed under the strenuous demands of war which now constitute permanent additions to our industrial equipment in the ways of peace. This is a listening instrument invented by the French for detecting enemy activities in sapping and mining and for locating artillery. It is being used by the Bureau of Mines for the locating of miners who have been entombed after a disaster. Although quite small it is essentially a seismograph, working on the same principle as the ponderous apparatus which records earthquake tremors.

The principal feature of the apparatus is an iron ring about three and one-half inches in diameter within which is suspended a lead disk which is fastened by a single bolt through two mica discs, one of which covers the top and the other the bottom of the ring. There are two brass cap pieces, the top one having an opening in its center to which is



Listening to blows of a coal pick 600 feet away

fastened a rubber tube, leading to a stethoscopic ear piece. These cap pieces are fastened with bolts to the iron ring and serve also to hold the mica discs in place.

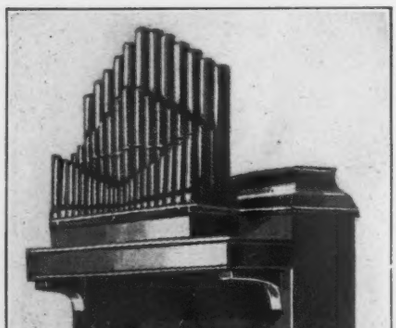
If the instrument is placed on the ground and any one is pounding or digging in the vicinity, energy is transmitted as wave motion to the earth, and the earth-waves shake the geophone case. The lead weight, on account of its mass and because it is suspended between the mica remains comparatively motionless. There then is produced a relative motion between the instrument case and the lead weight. The result is that a compression and rarefication of the air in the instrument takes place. Since the rubber tube leading to the stethoscopic ear piece is connected with this space in the geophone, this rarefication and compression is carried to the ear drum.

Usually two instruments are used, one for each ear. When the two instruments are thus used it is found that the sound is apparently louder in the instrument nearer the source of the sound. Then by moving the instrument properly a point can be found when the sound will be of the same apparent intensity in both ears, and the direction of the sound is then on a perpendicular to the line connecting the centers of the two instruments either in front of or behind the

observer. Direction is quite accurately determined in this way. The sound is not actually louder in one ear than in the other, but the ear is capable of distinguishing the difference in time at which sound arrives in the two instruments. Since this is the case, persons who are slightly deaf in one ear are said to still be able to determine direction with the instruments. Sounds are transmitted only about half as far in clay as in shale strata and about one quarter as far in clay, as in coal. Pounding with a pick on bituminous coal can be detected for a distance of 900 feet and pounding with a sledge can be heard as far as 1150 feet.

COMPRESSED-AIR CALLIOPE MADE FROM PLAYER PIANO

First cousin to the well-remembered steam calliope of the old-fashioned circus parade says a writer in *Popular Mechanics* is a compressed-air instrument of recent construction. This last word in calliopes has been built



around an ordinary player piano. Instead of depressing the keys, however, the fingers actuated by the perforated roll open and close the air inlets to the 49 whistles. These metal tubes are blown by compressed air from a tank fed by a rotary air pump. Syncopated tunes from the player calliope have proved tremenduously popular for open-air dancing and ice skating.

HELIX AND SPIRAL

These two words are quite generally used as more or less interchangeable, or in fact the latter mostly does duty for both while they really have quite different and specific meanings and applications.

The curve followed by a screw thread, or by a wire spring either to push or to pull is a helix, while an ordinary watch or clock spring is an example of a spiral, although it may not follow precisely the mathematical definition. A helix is the curve traced by a point rotating uniformly along a cylindrical surface and advancing at a uniform rate parallel with the axis. A spiral is located in one plane and has a constantly increasing or decreasing radius of curvature.

LEIPER QUARRIES OPERATED FIRST "RAILROAD" IN U. S.

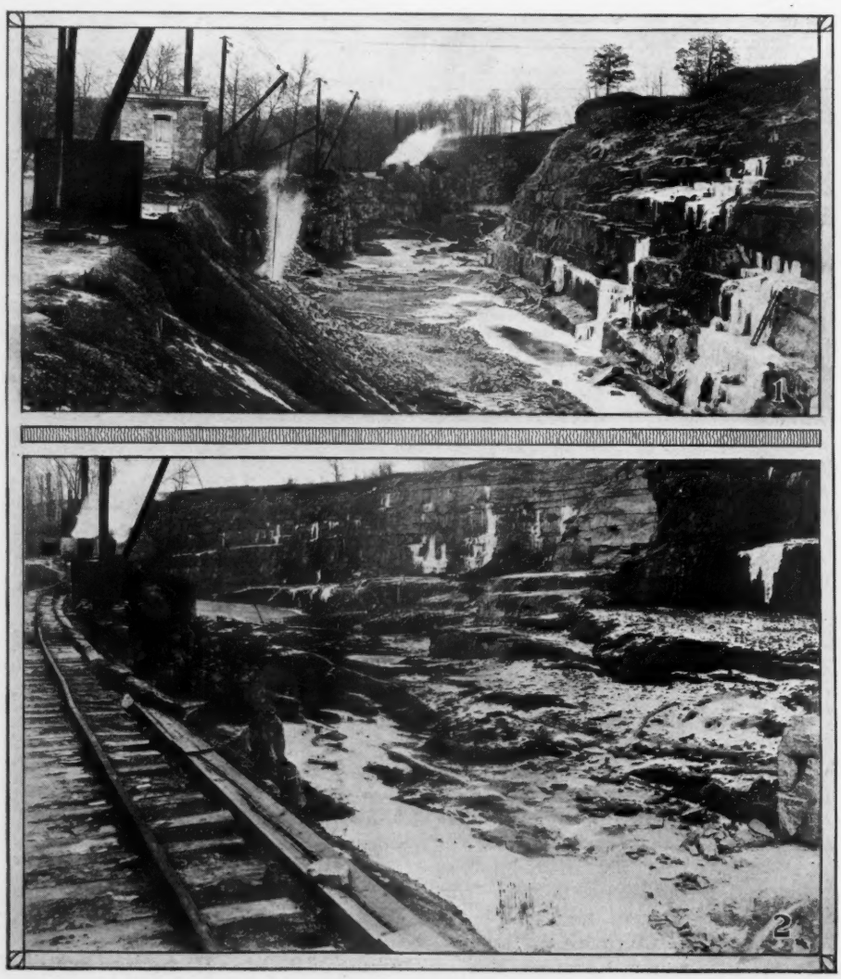
ABOUT one mile below Swarthmore, Delaware County, Pennsylvania, along the State highway to Chester, the Leiper Quarries rear their rugged cliffs. They are one of the noted sights of the county, for the sheer rock walls rise, tier upon tier, to the height of 100 feet or more and follow the windings of Crum River full 1200 feet. They are undoubtedly among the finest quarries in Eastern Pennsylvania, and "Leiberville Granite," as the micaceous gneiss deposit is known, has ranked high in Philadelphia and local markets since revolutionary days, as a superior building and curbing stone.

The quarries have been owned and operated by a Leiper since the days when Thomas Leiper, Revolutionary officer and ardent patriot, first took them in hand. A man far ahead of his times in introducing labor-saving devices, he applied to the State authorities for permission to build a canal to enable him to have a navigable stream from his Crum Creek plant to his landing on the Delaware, whence his fleet of sloops bore the stone to Philadelphia and other points along the river.

About this time he had advanced the theory that one horse could move a much heavier load if the truck were run over rails, instead of on the ground. A jeering crowd was present at the demonstration on High St., (now Market St.) Philadelphia, where he proved his theory to be eminently practical. So, when the right to build the canal was refused, he decided to turn his experiment in rail transportation to commercial use, and engaged John Thompson whose son later became president of the Pennsylvania Railroad Company, as engineer to lay out the road. This was in 1806 and it was the first railroad operated in the United States, although the motive power was only a yoke of oxen and the rails made of wood. This railroad was in use until 1832, when George Gray Leiper, son of Thomas Leiper, succeeded in obtaining permission to build the canal, which was opened with elaborate ceremonies and continued in use till the present railroad was built in 1852.

As the quarries have kept pace with transportation progress, so have they done along mechanical lines, introducing new labor-saving machinery as it appeared. As the ox-drawn stone car differs from the steam-drawn gondola, so does the hollowed elder twig, filled with powder and placed in the hand-drilled hole, differ from the line of holes drilled by pneumatic power and exploded by electricity.

The present owner has operated the quarries for 50 years and was the first in Delaware County to use Ingersoll machinery.



Views of the Leiper Quarries

AUTOMATIC AIR COMPRESSOR CONTROL

THE AUTOMATIC control of the output of an air compressor is generally highly desirable and often it is imperative while the problem is not a simple one. If the consumption of the air were constant no more regulation of the compressor's speed and power would be required than that given by an ordinary steam engine governor to provide for the fluctuations of boiler pressure or to guard against possible accident. But most air compressors work under such wide variations of demand that it is necessary to make provision for economical running. When a sudden temporary decrease in consumption of air occurs, it is necessary either to slow down or to blow off the air at the receiver safety valve. A cubic foot of compressed air, however, is costly, far more costly, as a matter of fact, than a cu. ft. of steam. What is desired, therefore, is a device that regulates the work of the prime mover in accordance with the demand on the compressed air.

Devices and arrangements for this purpose have been described in COMPRESSED AIR MAGAZINE from time to time and their number is continually increasing. We present here brief sketches of three different arrangements put forth by an English firm, Reavell & Co., Ltd., Ipswich.

Fig. 1 shows this device in action. It is bolted direct to the outlet of the compressor and is in the form of a by-pass valve, making a connection between the delivery and the atmosphere. It is automatically controlled by an air relay connected to the reservoir so that when the air pressure reaches the desired limit, the by-pass valve opens and the delivery chamber is put in communication with the atmosphere. The load is thus removed from the driving pulleys or from the motor, if the machine is so driven. As soon as the pressure falls to a predetermined limit, this valve closes and the compressor commences to deliver again.

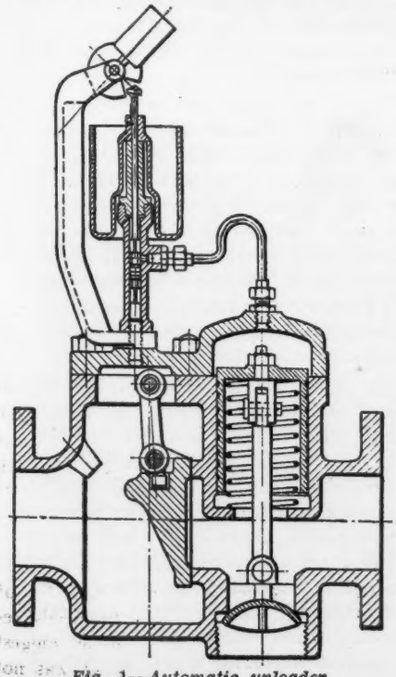


Fig. 1—Automatic unloader

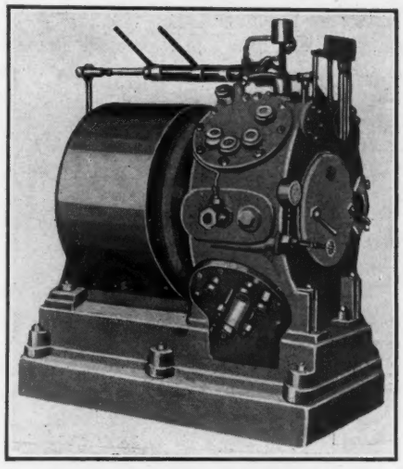


Fig. 2—Compressor with belt shifter

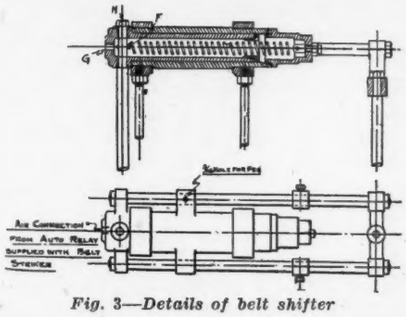


Fig. 3—Details of belt shifter

This device is arranged to push the belt on to the loose pulley when the maximum pressure is reached, and when the pressure falls the belt is pushed on to the driving pulley again. When tried it was very sure in action and is also very compact. This simple arrangement is clearly shown on the compressor in Fig. 2, and in section in Fig. 3.

The latter of these two appliances is suitable for belt-driven machines only, but there is no reason why it could not be applied to shifting a clutch in the same way. The first device is wasteful as regards power, because a certain amount of power is required to turn the machine round to deliver air against the valve resistance, which is not the case with the belt-shifting device, but if overload is only for short periods, it is certainly better than the second, as the starting torque on the compressor, after stopping, takes up much energy.

In the use of compressors driven by continuous current motors, two systems of regulation are adopted in practice. Where the machines worked by compressed air are in intermittent use and varying volumes of air are required at a constant pressure, such as for haulage engines and pneumatic tools, most efficient regulation is obtained if the compressor is varied in speed to correspond with this variation. To attain this a motor of the "variable speed" type must be adopted, and an automatic controlling switch and resistance fitted.

Such a switch and resistance is illustrated in Fig. 4.

The regulation is effected by varying the current passing through the shunt windings, and, therefore, it is very economical. Any reduction in the speed of the motor gives an almost proportional reduction in the current consumption.

When the machines to be supplied with compressed air are in almost constant use, and are either all working or all stopped together, it will be found most economical to use a fixed speed motor and have an automatic stopping and starting switch. This will stop the machine when the pressure in the mains or receiver reaches a certain maximum owing to a cessation in the demand for air, and will restart it when the pressure falls to a predetermined minimum. The means of regulation entails the use of an air reservoir of considerable size. This is the type of regulator that Messrs. Reavell employ for their own works.

It consists essentially of a dial pressure gage whose hand has a renewable carbon tip. On the face are two brass rings, an outer and inner. Sliding on these rings and forming a contact are two carbon bobbins, and these can be set at any pressure. The bobbin on the inner ring is set at the point of maximum pressure, as shown on the ordinary gage by a number. The outer bobbin is placed at the point of minimum pressure. The hand, therefore on coming in contact with the top bobbin cuts out the current, thus stopping the motor and incidentally the compressor. The pressure, when it drops, causes the hand to fall, which makes contact with the lower bobbin, which thus starts the machine again.

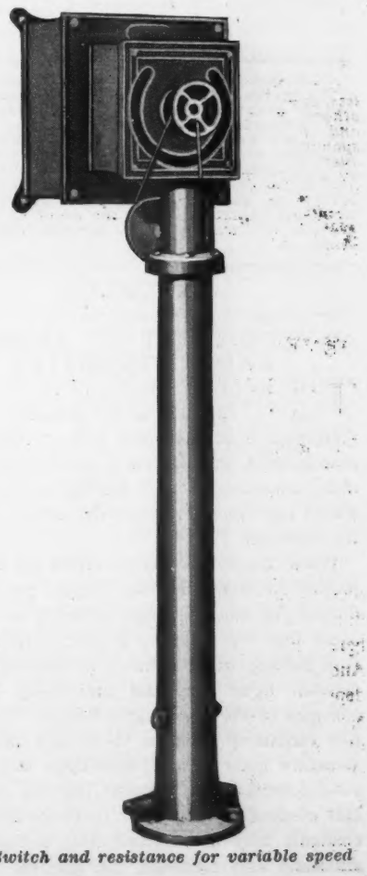


Fig. 4—Switch and resistance for variable speed

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EDITORIALS

DEVELOPMENT OF AMERICA'S EXPORT INDUSTRY

THE RECENT election of the Hon. WILLIAM C. REDFIELD to the presidency of the American Manufacturers Export Association assures that organization a continuation of the able, experienced and intelligent leadership which has always marked the eleven years of its existence.

While much has been written on the subject of America's Foreign Trade, particularly during and since the war, it should be remembered that this industry is still in its infancy. And like any other industry its healthy growth depends upon time and the wisely directed energies of the men engaged in it. Constructive measures must be taken and the whole structure must be built step upon step on the solid foundation of honesty, service and correct economic principles. In order that these elements may be realized it is necessary to stimulate and maintain the interest of men who are leaders of industry, and that they in turn give their time and experience in aiding the development of the export trade of the United States. These outstanding facts were stressed by practically all of the speakers at the recent annual convention which was attended by more than 1,000 manufacturers and others interested in foreign trade.

The newly-elected president summed up the situation in one paragraph of his message to the members of the organization as follows:

"The situation is a practical one; we face realities, not dreams. They need to be treated without passion, prejudice, or partisanship, but with thorough knowledge of the facts and with courage and far vision. Obviously, former methods will not be adequate to the novel circumstances in which we stand. There must be an adjustment to new conditions. We must as soon as may be, revise present organizations, or create new ones in order to provide for our commerce organizations, as effective, and powerful as those with which our competitors have long been supplied. There is every reason for faith in American wisdom, initiative and courage, for calm confidence that we shall be able to meet the situation adequately and in the final result that we shall hold our normal place as one of the greatest factors in international trade."

The establishment of an American export industry is not a question of a year, nor a decade, but of generations. America's entry into foreign fields is the natural outcome of years of existence as a producing nation. With immense deposits of iron, coal, copper, petroleum, zinc and numerous other mineral deposits, and with the greatest facilities for agricultural purposes, America was content to devote her efforts to the exploitation of these natural resources. At the present time, with adequate plants and equipment capable of immense production, it is but natural for America to look for markets outside of her borders to dispose of supplies not required for domestic uses. To supply products which can be best and cheapest manufactured in this country to the people of other nations is the surest foundation of a permanent and profitable industry.

The retiring president, Mr. WILLIAM L. SAUNDERS in an analysis of the present foreign trade situation and its needs mentioned a number of factors that make the situation "unfortunately a very complicated one involving questions of exchange, economics, currency inflation, etc."

Continuing Mr. SAUNDERS pointed to a very important phase of the export business when he said: "And now we come to the keynote of this meeting—in order to obtain world trade, American manufacturers must now take a leading part themselves. How can this best be done? In the first place, manufacturers are not bankers. The critical situation in our foreign trade itself is one of finance. It involves banking and investment problems. This is not our job. If it were we should probably be less efficient in production. Surely we do not wish to adopt the German system in which the banks control the industries. Let us rather lean toward the industries controlling the banks. A manufacturing business requires large capital and a quick turn-over. Without a quick turn-over prices go up through excessive overhead. . . .

"The machinery has already been provided through legislation by which this financial side of foreign trade may be properly handled. I refer to the Webb Law, which permits combinations and price fixing in exports, and the Edge Law, which provides banking and investment machinery. Let us suppose that an Edge bank was located in England and another in France and another in Italy. These banks might be controlled by investors with a centralized Edge bank in New York. When manufacturers seek to finance a trade in the Orient, for instance, involving many months of time credits, they should go to their banks and the banks should go to the Edge bank to aid them in credit information and in financing. This, it seems to me, is the only practical way by which we manufacturers can hope to do our part in organizing permanent machinery for world trade."

The bankers of the country have recently formulated a nation wide foreign trade financing plan by the creation of a corporation to have a capital of $100,000,000 and a responsible and thoroughly efficient personnel. This has been a national need and adds an important cog in the complicated machinery essential for carrying on any large amount of export trade.

Coöperation between all classes of business men is a patriotic duty as well as an act favorable to the very best interests of a war oppressed humanity.

OUR MOST ANCIENT BUILDING

WE COULD not well have been expected to have had the erection of the great Cunard Building going on right next door to us, and intrusively and continuously before our eyes for several months, without finding ourselves more or less mentally stirred and quickened thereby. It has indeed given us many things to think of, and compelled the thinking, in spite of ourselves.

The world famous and enduring dictum of Lord Bacon confronts us. "We are the Ancients"; and if this be so, as we all concede, then surely, as our title above suggests, here is our most ancient building. We may well believe, and in fact we must believe, that it would not have been possible of conception and construction in its entirety when the world was only a quarter of a century younger. Astonishing as may be the suggestion the facts in substantiation are closer at hand.

The entire quadrangle enclosed by Broadway, Bowling Green, Greenwich Street and Morris Street has now and hereafter but three occupants: Washington Building, Bowling Green Building, Cunard Building. The first of these, built within the memory of men scarcely past middle age, was still built before the Age of Steel. Its interior columns are of cast iron and its supporting exterior walls are of heavy masonry. It is being so drastically reconstructed and "modernized" as to suggest the general wondering query why it was not all pulled down and rebuilt from the founda-

tion. Of the Bowling Green Building we can necessarily speak only respectfully. Built perhaps a decade later than the other, and then the marvel of its day, it has lately found it necessary to add two or three stories to its stature and do a general sprucing up.

These three buildings thus curiously grouped together and illustrating successive stages of development seem inevitably to suggest some other erection to come after with no long interval between. It is not for us to attempt to specify the particulars by which our latest architectural acquisition may be expected to assert its momentary supremacy. The only thing apparently certain is that the world will still continue to grow older, and we may assume that its advance, at least for some time to come, will not be along unfamiliar lines and that the most ancient building of to-day will not be put to shame by the more ancient building of the day after to-morrow. We feel encouraged and strengthened rather than otherwise by the revelations of Sir Christopher Wren's slackness concerning the foundations of St. Paul's, and we can testify from personal overlook that no such stories will ever be whispered about the Cunard Building in New York. R.

COMPRESSED AIR INCREASES PETROLEUM PRODUCTION

MANY REMEDIES have been urged to solve the existing shortage of petroleum, which is embarrassing the automotive, shipping and railway industries and hampering their development. The manufacture of gas engines, the building of oil burning ships possessing a large cruising radius, and oil burning locomotives, all depend upon crude petroleum and its distillates, not alone for fuel but for lubricants which are absolutely necessary for the reduction of friction.

A number of these proposed remedies contain much merit and undoubtedly would alleviate the difficulty even though they would not provide a specific cure. The majority of these methods attack the problem from one angle, namely, a more economical use of the present production. The development of low gasoline consumption engines has been suggested. The construction of engines to burn some product of petroleum other than refined oil has also been suggested as well as the reduction in horsepower of heavy cars and the lowering of speed limits.

However, no one knows exactly what supplies of this wonderful fuel are still hidden beneath the earth's crust. New supplies are being reported at frequent intervals and it might be well to consider this phase of the subject. From a report of Mr. J. O. Lewis, chief petroleum technologist of the U. S. Bureau of Mines, it has been frequently quoted that compressed air forced into the oil sands of the semi-exhausted wells in Pennsylvania resulted in an increase of from 50% to 100%, which promises eventually to relieve a part of the oil shortage in the country. There is nothing new about the method as it has been practiced in a number of oil fields for years.

Air is forced down abandoned wells and drives large quantities of oil into the wells that have not been abandoned, resulting in some cases in doubling the output. This compressed air acts as a partial remedy for the absence of the natural gas which is usually present in an oil well, at pressures ranging as high as 1200 to 1400 pounds to the square inch, which forces the oil to the surface. However, when this gas has escaped and the pressure is relieved, it must be replaced in order to obtain anything like the former production.

This compressed air process, we understand, is being introduced in the mid-continent fields of Kansas, Oklahoma and Texas. Investigations that are being conducted by the Bureau of Mines into this use of compressed air to increase oil production indicate that in abandoned wells are still stored large supplies of oil. The Bureau, however, has as yet no definite estimate as to the quantity of oil it may be possible to realize in this way. Mr. Lewis says in part:

"On many old properties in the Eastern fields the compressed air process has increased the recovery from 50% to 100%. We do not know what will be the results of the compressed air process. There are indications in a number of instances that only 10 to 20% of the oil in wells has been recovered under the ordinary pumping process. If the compressed air drives the remaining oil from the sands, there is no telling how much more oil may be brought to the surface."

A distinguished southwestern geologist was recently quoted as saying, "that probably not more than 25% of the oil in the oil-bearing formations in the north central Texas field is being taken out, thereby leaving 75% in the ground."

The more general application of compressed air in the oil fields for the purpose above described therefore would seem to possess far reaching possibilities. Theoretically, it is sound, and we already have had results from its practical operation and it is hoped that the technologists of the Bureau of Mines who have been so successful in solving other economical problems will find that by this use of compressed air a decided increase in the production of oil wells will result.

TOOK RICHES FROM AIR FOR HUMANITY'S BENEFIT

A DESCRIPTION from the pen of James B. Morrow of how Dr. Frederick Cottrell, head of the United States Bureau of Mines, took riches from the air, and presented them as a gift to humanity, is told strikingly in a recent issue of *The Nation's Business*. Mr. Morrow calls Doctor Cottrell, whose appointment to his new post, in succession to Dr. V. H. Manning, was commented upon in these columns, one of America's great philanthropists as well as one of its great scientists. In some respects, the work of the fine foundations of Rockefeller and Carnegie, seem common-place by comparison with Doctor Cottrell's achievements.

Doctor Cottrell has the distinction of practicalizing and applying the discovery of the precipitation of suspended matters in gases and liquids by means of electricity. This discovery was made a century ago when a teacher of mathematics in Leipzig found that if he electrified a wire hung in a bottle filled with smoke that the smoke disappeared and left a deposit on the sides of the bottle.

At this moment in Montana the bottle has become a chimney 586 feet high and 86 feet in diameter. The wire has become 111 miles of electrified chains suspended between huge plates. The smoke has become the dust and fumes of a great copper reduction plant. When the plates are deeply coated the electricity is cut off and the accumulated particles fall into hoppers.

Smoke, dust and vapor from kilns and smelting works and from roasters and lead furnaces were being poured over orchards and fields in California fifteen years ago. Farmers, whose property and crops were being injured or destroyed, had gone to the courts for relief. Invisible sulphur dioxide, sulphuric acid, arsenic and lead salts and visible particles of lime filled the air in some of the richest agricultural regions of the Pacific Coast.

Such was the state of things in 1905. Frederick G. Cottrell, aged 28, was then an instructor of physical chemistry at the University of California, where he had been graduated when he was nineteen. In Germany, while a student at Berlin and Leipzig, he had noted the close relations that existed between the small colleges of Germany and the manufacturing classes. Professors, working in obscure laboratories, often made discoveries of great value to industry, and German products were being sent all over the world.

The precipitation process was first employed in the cement industry at Riverside, California, where one company after spending a million dollars in the purchase of surrounding land and machinery to stop complaints and end the nuisance finally spent $200,000 to install the Cottrell process. The outlay resulted in the collection of nearly 100 tons of dust a day. Enough potash was obtained from the dust to pay a large dividend on the money invested in the new machinery.

Since then the process has been adopted by many cement works in other parts of the country, and owners of iron furnaces are using it for utilization of smoke and gases.

Experts say that the only sources of a cheap and permanent supply of American potash seem to be the cement kilns and the iron furnaces, from the dust of which, by the Cottrell process of filtration, large quantities may be procured. It is said that one cement company alone is recovering potash to the value of $6,000 weekly.

Doctor Cottrell has given his patent to the public. In explaining the unique and unselfish action of Doctor Cottrell and his associate the Research Corporation says: "In 1911 an offer was made to transfer as a gift to the Smithsonian Institution extensive rights in the Cottrell patents covering the process known as the electrical precipitation of suspended particles, in order that the profits resulting from the application of the patents, already well assured, might be applied to the advancement of scientific research and investigation.

"Naturally," the corporation goes on to say, "this proposal was at once recognized as both generous in spirit and highly original in con-

ception. The idea, which originated with Doctor Cottrell, was to render discovery already made, the mother of new discovery and thus contribute to the scientific and technical development of the industrial arts."

The profits derived from the patents are to form "an endowment fund to be used for the intensive study of scientific and industrial needs and to provide the means, through the testing of new discoveries and through study, investigation and experimentation, of applying such needs."

In the years that Doctor Cottrell toiled over his invention he earned his livelihood by teaching. And when wealth was at hand he turned it away. Since 1911, Doctor Cottrell has been attached to the United States Bureau of Mines—first as a consulting chemist, then as a chief physical chemist working in the field, then as chief chemist and then as chief metallurgist. Not long ago he was appointed director, becoming the highest officer in the bureau.

THE WORLD'S SHORT SUPPLY OF OIL

Floyd W. Parsons has made for himself a unique position in the pages of the *Saturday Evening Post*. His touching up of "Everybody's Business" is admirably beneficent with scarcely an exception as to the topic of the moment. In his latest word that has come to us he "relieves his conscience" in the matter of the substitution of oil for fuel in the place of coal, and it would have been upon our own conscience if we had failed to reproduce and pass along his words of warning which will be found upon another page of our present issue.

The case as he presents it is incontrovertible and is sufficiently alarming as to our economic and industrial future. Steam has given the impetus to civilization for now more than a century, and its drive was never greater and its continued thrust more depended on than now. Backing our steam is the fuel by which it is generated and for this until very recent years we have depended implicitly upon coal. Just now we have been realizing that oil may be used for steam raising in place of the coal, and with some accompaniments altogether gratifying. It is clean and handy and labor-saving in the handling, so that it brings its temptation with it.

But—and the but is a large one—it happens that while oil may thus be so smoothly substituted for coal the relations of the two are not in the least reciprocal, for coal cannot possibly be substituted for oil. The latter has a two-fold function in our industries and the use of it for fuel is by far the least important. Oil is the great reliance of the world for the lubrication of its vast labyrinth of machinery, and without the oil the wheels must stop.

With oil thus so necessary or practically the world's sole lubricant it is a self-evident waste and perversion to consume and destroy it by burning it away. This would be bad enough if coal and oil were otherwise upon equal terms, which they are not. The world's supply of oil is known to be extremely limited, and the time that it can last is so short that those best informed about it are almost counting the years by single units, while the visible and known supplies of coal are similiarly counted by centuries.

We must confess that, with others, we have not been in the habit of looking into the matter with much seriousness. We have had only the current general information on the subject, but even at that we have regarded with some surprise the recent conversion of the biggest ocean liners into oil burners, but have contented ourselves with the assumption that the steamship companies have known what they were doing.

Some things are sometimes accomplished by the enactment and enforcement of stringent laws, and no more urgent occasion for them can well be suggested at the present time than in the conservation of what remains of our failing oil supply. R.

Following the same line of thought is this statement of Gilbert and Pogue, of the Mineral Technology Division of the United States National Museum: "Unfortunately, the swing away from coal in favor of fuel oil still continues. The possibilities of oil-energized automotive agencies are so great and vital that before long it will be looked upon as an inconceivable folly that oil should ever have been used for steam-raising, the most glaring economic perversion that this country has ever been guilty of. It is absolutely essential to turn the tide back toward coal. If coal cannot meet the issue, our industrial activities must be curtailed. There is no other way out."

Coal is used wastefully, which is a fact no one can deny. It is probably true that in the average power plant for every dollar's worth of fuel put under the boilers less than two cents' worth ever reaches the finished product in the way of direct power. But our extravagance in the burning of coal is being gradually rectified, and in the meantime, notwithstanding our waste, we still have centuries of supplies here in our mountains and prairies. On the other hand, just imagine for a moment the extent of the calamity to civilization should our oil resources become exhausted. Eliminate gasoline, and where would be our automotive industries? Eliminate kerosene and lubricating oils, and see what would happen to the world's great industries. All the machines in every American plant are wholly dependent upon an adequate supply of lubricants. Anyone who is debating the question of whether or not to substitute oil for coal for fuel purposes should give careful consideration to all such facts.

Ice will float upon liquid oxygen, which has a specific gravity of 1.13, but it will sink in liquefied nitrogen, the specific gravity of which is 0.81. The specific gravity of ice, which is therefore between these, is 0.9175.

Phonograph needles which play with a very clear tone are being manufactured from clay.

Chase Securities Corp. and American Can interests are in accord with the formation of a new corporation known as the American Motor Body Co.

SALT FROM SEA-WATER BY ECONOMICAL EVAPORATION

A process has been invented in Norway for the extraction of the salt in sea-water by evaporation. A specially designed plant is used, which embodies the principle of regeneration, but is without the difficulties hitherto encountered when evaporation is attempted on a large scale. Brine is circulated through a nest of vertical tubes, the outsides of which are heated by steam, thus producing active evaporation. The resultant vapor from the brine is exhausted by a pump, is compressed adiabatically and also forced into the steam space around the tubes. The heat of evaporation is thus retained and is used over and over. It is claimed that the makeup heat required to maintain the process is very small, and that one pound of coal is sufficient to evaporate 800 pounds of sea-water. It is further claimed that, by concentrating brine from 3 per cent. to 25 per cent., with a final difference of only 40 degrees centigrade, a kilowatt year will transfer 15.6 tons of salt to the higher concentration, and that it is possible to obtain 62.4 tons of concentrated brine per kilowatt year.

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PROGRESSIN'

By D. E. A. CHARLTON

Sez Cap'n Jan, a minin' man, "I used to think I nawed
"About as much o' drills an such as any man 'oo grawed.
"But 'ere," sez 'e, "I'll say to thee, I've changed my min' a bit,
"For I 'ave lived for fifty years, an' now I'm loath to quit."

"M'son, I've foun' in goin' roun', there's knowledge an' to spare,
"An' 'e 'oo thinks 'e naws it all ain't some'ow playin' square.
"That is to say, 'e's got to pay tha price o' losin' much
"That h'others get, w'ile 'e 'imself goes 'obblin' on a crutch."

"It used to be, I'll say to thee, that none could tell me 'ow
"To drive a drif' or sink a winze without I'd 'ave a row.
"A minin' man," sez Cap'n Jan, "Mus' keep abreast o' time,
"Learn better ways o' doin' things an' use them at tha mine."
"I've learned a lot, an' like as not I may pick up some moor
"O' stopin', an' o' driftin', an' tha ways o' 'handlin' h'ore.
"For, min' you, lad, there can be 'ad a drill for every groun',
"An' so it is with every job, some short cut can be foun'."

TUNNEL PROBLEMS UP TO THE GOVERNMENT

George S. Rice, chief mining engineer of the Bureau of Mines, recently made an extended tour through the West. Several of the cities which he visited have vehicular tunnel projects under consideration. He also looked into the proposal to drive the six-mile Moffat tunnel in Colorado. Before the Moffat railroad is extended to Salt Lake City, it is proposed to drive a double tunnel to prevent the almost prohibitive grades which otherwise would be necessary. The Bureau of Mines has been conducting research on mine gases for many years. A year ago, the bureau was solicited by several eastern cities, interested in vehicular tunnel construction, to co-operate in a study of the effect of the exhaust gases from automobiles in long tunnels. Congress declined to allow any appropriation for this work, but it is believed that the appropriation failed from the desire to eliminate all new items from the appropriation bills. It is believed, or at least hoped, that the next Congress will be more generous, especially in view of the widespread demand for authoritative data, not only in the matter of gases in tunnels but in the whole matter of ventilation during construction and subsequently.

According to a statement issued by the National Foreign Trade Council, the capital invested in the German automobile industry has increased since 1915 by approximately 25,000,000 marks.

Book Reviews

EXPERIMENTAL WIRELESS STATIONS, by P. E. EDELMAN, author of *Inventions and Patents, Experiments*, etc. 1920 edition, 320 pages, 167 illustrations. Price $3.00, New York, The Norman W. Henley Publishing Co.

THIS VOLUME treats of the theory, design, construction and operation of wireless stations, including wireless telephony, vacuum tube, and quenched spark systems. It tells how to make apparatus to hear not only all telephoned and telegraphed radio messages, but also how to make simple equipment that works for transmission over reasonably long distances. There is a large amount of new information included and the volume anticipates every need of the reader who wants the gist of the art, its principles, simplified calculations, apparatus dimensions and understandable directions for efficient operation.

Vacuum tube circuits, amplifiers, long distance sets, tables of wave lengths, capacity, inductance, etc., are only a few of the subjects presented in detail that would be invaluable to instructors, and also to the amateur for dependable designs.

ADVERTISING THE TECHNICAL PRODUCT, by Clifford Alexander Sloan, vice President, Campbell-Ewald Co.; formerly vice-president Rickard and Sloan Technical Agency; advertising manager, Hyatt Roller Bearing Co. and James David Mooney, vice-president's staff, General Motors Corporation; special lecturer, New York University; member, American Institute of Mining and Metallurgical Engineers, American Society Mechanical Engineers' Society American Military Engineers. New York; McGraw Hill Book Co., Inc., 365 pp., illustrated.

THIS BOOK is an excellent practical treatise on scientific technical advertising and the author's handling of the whole subject is to be particularly commended. The practical nature of the discussions is assured when it is realized that the list of contributors is made up exclusively of advertising managers, publishers, purchasing agents, sales managers and executives connected with organizations of national prominence and are men of pronounced success in various phases of the work under consideration.

This book performs a real service, presenting a comprehensive review of the present status of the advertising situation as it exists today and the various problems which industrial concerns must meet in carrying on technical advertising campaigns.

As is stated in the preface, these texts here and there, steps on some one's toes. This is not the result of a conscious effort on the part of the authors to "reform" practice. The practice of advertising technical products does not need reforming, we are told, as it is too highly developed and governed too generally by the intelligent application of sound advertising and selling principles. The authors simply have disagreed here and there with phases of practice and have said so frankly. A book of this kind must be frank to be constructive.

In the introduction to the volume, it is stated, that a great deal of research will be made to provide more accurate means of weighing and measuring the effective factors in advertising. Assuredly manufacturers would heartily welcome any improved method of measuring results from a certain definite amount and kind of advertising. Indeed according to present day standard methods advertisers are to a certain extent forced to work in the dark. Results are judged to an extent in the ultimate and a close analysis of the value of various mediums and direct and indirect methods cannot be made.

For a complete survey and to convey a thorough understanding of the purposes, methods and results of advertising, this volume can be recommended and certainly it will find its way into the office of every progressive advertising man.

MOTOR BOATS AND BOAT MOTORS, by VICTOR W. PAGE and A. L. LEITCH. 512 pages, 357 illustrations. Price $4.00, New York. The Norman W. Henley Publishing Company.

ALL WHO are interested in motor boats, either as owners, builders, or repairmen will find this latest work a most comprehensive treatise on the design, construction, operation and repair of motor boats and their power plants. It is really two books in one cover as it consists of two parts, each complete in itself. Part One deals with the hull and its fittings, Part Two considers the power plants and its auxiliaries. A valuable feature of this book is the complete set of dimensioned working drawings detailing the construction of five different types of boats. The plans, by A. C. Leitch, are complete in every particular. Valuable advice is included on boat and engine operation and the latest designs of motors are described and illustrated. This book is a comprehensive work of reference for all interested in motor boating in any of its phases.

E. P. M.

The land owners under the Government project in the Okanogan Valley, Washington, are preparing to install one of the most powerful steam pumping plants ever used for irrigation purposes. It is proposed to lift sufficient water out of the Okanogan River to irrigate 5,300 acres of land now in bearing orchards in the vicinity of Omak. This water will have to be lifted to the total height of 470 ft. and pumps having a capacity of 25,000 gal. per min., will be required for the work.

The members of the American Society of Mechanical Engineers have organized themselves into a professional section on the subject of Aeronautics. Howard E. Coffin, Jesse G. Vincent, Orville Wright, are among those who have registered in the section, and as Chairman of the Advisory Committee on Aeronautics, Mr. Coffin sent the first American delegation to the London Conference on Aircraft in the spring of 1919.

The National Foreign Trade Council, at its seventh annual meeting in New York, selected Cleveland, Ohio, to hold the Eighth National Foreign Trade Convention, scheduled for the spring of 1921. It was thought that as the 1920 Convention had met in San Francisco, the 1921 Convention should be held in an inland city.

Notes of Industry

The world's largest crane is located in the Philadelphia Navy Yard. It is of the hammer-head type, 230 ft. in height, and is capable of lifting 350 tons on a reach of 115 ft. Three 14 in. guns mounted in a single turret and weighing about 300 tons will be an ordinary lift for this gigantic piece of machinery.

A company known as the American Compressed Air Motor Co. has been incorporated at Wilmington, Del., with a capital of $100,000.

There are three theories for the formation of the nitrate of soda bed in the desert of Chile: The deposit from an ancient sea which was raised above its former eruption, and its waters evaporated; the deposit from saline residues of fresh water streams; due to the nitrification of guano.

South Africa imports ordinarily about $12,000,000 worth of hardware per year, according to a report on the subject prepared by American trade commissioners Landquist and Williams, and more than $2,000,000 worth of this business now comes to the United States.

The Wilson dam, at the present time being constructed two miles above the city of Florence, Ala., near the foot of Muscle Shoals in the Tennessee River, is about one-fourth completed. It is expected that it will be completed in 1922, and at that time Alabama will have the largest power dam in the world. This dam will be 4,200 feet long and 96 feet high above the bed of the river. About 4,000 men are employed on this work at present, and it will take two years to place the concrete which is going into the body of the dam. Colonel Lytle Brown is in charge of the work for the Government, being at the head of the Board of United States Engineers, which includes also Major Stuart Godfrey, Major Taliaferro and Captain Bullard.

The Kerchoff power unit of the San Joaquin Light & Power Co., San Francisco, Cal., was opened late in August after fifteen months of construction.

Large discoveries of iron ore at Koursk, Russia, have been made by two Swedish scientists who have been following up the investigations made by the late Russian Professor Ernst Leyst of Moscow. At the present time it is not possible to arrive at anything like definite results as to the quantity and quality of the ore present, but these experts are of the opinion the deposits will be found to be the largest in the world.

The Joint Conference Committee of the Federated American Engineering Societies has announced five additional members as follows: Engineering Association of Nashville; American Institute of Chemical Engineers; Engineering Society of Buffalo; American Institute of Mining & Metallurgical Engineers, and Society of Industrial Engineers.

ALL WANT TO ADOPT HIM

The production of bituminous coal during the week of September 25 totaled 11,817,000 tons, the biggest week since January. Anthracite coal production in week ended September 25 was 1,650,000 tons.

White Oil Corporation has entered the Cat Creek field, Montana, having formed an organization in that district, with headquarters in Lewiston.

The world's largest wireless station will soon be in operation. It covers 6,400 acres on Long Island and is more powerful than either of the radios at Bordeaux, France, or Nauen, Germany.

The Reservoir Quarry Company has been organized at White Plains, N. Y., with a capital of $25,000 to operate local stone properties. The company is headed by C. W. Knowles, U. M. Austin and R. M. Hart, all of White Plains.

The Matheson Products Company will shortly commence to manufacture brick at their plant at Matheson, Ontario. They expect to turn out 20,000 bricks per day at the start, but in a short time hope to increase this amount five times.

The Griscom-Russell Co. has issued a new Bulletin, No. 260, on the Reilly Heater. This heater has been on the market for a great many years and is the original multi-coil heater. The construction is simple, of light weight, and the heater is easily installed. The heating surface consists of interchangeable coils of seamless drawn copper tubing, attached to top and bottom manifolds by the patented screwed union Reilly joint. This metal to metal joint eliminates any possibility of leakage and also facilitates the easy removal of the coil.

The Sprague Electric Co. has issued a new Bulletin No. 48961, describing their electric hoists. These hoists are built in capacities from one-quarter of a ton to six tons, and in two general types: Worm geared hoists, Type W, and Spur geared hoists, Type S.

An order for three 15,000-ton tankers has just been placed by the Standard Oil Co. of California with the Union Iron Works, San Francisco. About $9,000,000 is involved in the order.

To freshen typewriter ribbons a tubular container for ink which is distributed by a roller as a ribbon passes over it has been patented.

Plans for a two-million dollar water power project of a St. Paul corporation, which includes a dam in the Saint Croix river near Rush City, Minn., have been made public. Application has been made to the Government for a permit to dam the river, but no action can be taken until permission from the Government has been received. It will require eighteen months to construct the plant.

The gold exported to the United States in September is officially given at £6,188,000; to British India, £523,000.

It is reported that airplane service between the United States and Cuba will be begun this autumn.

A recent British patent is to cover an ingenious adaptation of war material to useful, peaceful purpose. A ten-ton hydraulic jack is made with a 4.5 high explosion shell and an 18 pounder shell as its principal members. The big shell forms the body and the other the ram, while the pump cylinder is made from a piece of .303 rifle barrel.

Latest U. S. Patents

SEPTEMBER 28

1,353,857. RESPIRATOR. Detlef Karl Heinrich Schumann, Hamburg, Germany.
1,353,886. PNEUMATIC ANTIVIBRATION DEVICE FOR AUTOMOBILES. George W. Bell, Detroit, Mich.
1,353,897. HYDRAULIC AIR-COMPRESSOR. Herbert M. De Witt, Denver, Colo.
1,353,953. APPARATUS FOR GATHERING MOLTEN GLASS. Joseph B. Graham, Evansville, Ind.
1,353,966. SUCTION-HEAD FOR DISK GRINDING-MACHINES. William A. Lorenz, Hartford, Conn.
1,353,976. VACUUM-TUBE DEVICE. Erwin R. Stoekle, New York, N. Y.
1,354,017. PRESSURE-GAGE. Junius A. Bowden, Los Angeles, Calif.
1,354,035. ROTARY COMPRESSOR. Bion B. Farnham, Kenmore, N. Y.
1,354,056. PROCESS OF SEPARATING MIXED GASES. Fred E. Norton, Worcester, Mass.
1,354,124. MOLDING-MACHINE FOR FOUNDRY USE. John Birch Neesham, Glasgow, Scotland.
1,354,190. AMMONIA-COMPRESSOR. George Hilger, Chicago, Ill.
1,354,228. FLUID-PRESSURE TRANSMISSION. George E. Thompson and Phillip A. Udall, Stockton, Calif.
1,354,286. METHOD OF AND APPARATUS FOR MELTING AND CASTING METALS. Jean Hubert Louis De Bats, Stoneham, Mass. 2. The method herein described which consists in melting and casting in a single integral structure from which air is excluded.
1,354,340. CENTRIFUGAL VACUUM-PUMP. Victor Rosenhagen, Bellevue, Ky.
1,354,348. FLUID-ACTUATED RECIPROCATING MOTOR. William A. Smith, Easton, Pa.
1,354,355. SIGNAL DEVICE. Edward E. Tryon, Hartford, Conn.
1,354,380. APPARATUS FOR PRODUCING LIQUID OXYGEN. Charles F. Crommett and Orrin J. Crommett, Chelsea, Mass.

OCTOBER 5

1,354,482. PNEUMATIC SHOCK-ABSORBER. Josef Hofmann, Baumaroche, Switzerland.
1,354,592. FLUID POWER-TRANSMISSION APPARATUS. Joseph H. Bair, Philadelphia, Pa.
1,354,643. LOCK FOR AIR-HOSE COUPLINGS. Richard W. Brower, Proctor, Minn.
1,354,666. MILKING-MACHINE. Frederic A. Lane, Little Falls, N. Y.
1,354,750. GRAIN-CLEANER. Horace A. Holtan, Falkirk, N. D.
1,354,833. PNEUMATIC-TOOL-VALVE PROTECTOR. Harry Keller, Chicago, Ill.
1,354,916. AUTOMATIC SPRING-FAN. Paul Pys, Detroit, Mich.
1,355,035. BRICK-CLEANING MACHINE. Joseph Collins and Markus L. Askew, Hopewell, Va.

Recent British Patents

146,706. PNEUMATIC HAMMER. Howard Pneumatic Engineering Co., Ltd., and P. C. Bird of Eastbourne.
146,661. ROCK DRILL. W. E. Nettle, P. Selby, J. Blythe, and J. H. Holman, of Johannesburg.
146,044. COMPRESSOR. S. Larsson, of Stockholm.
145,939. ATOMISING APPARATUS. F. Thorp, H. T. Thorp and The Textile Illuminating and Engineering Co., Ltd., of Manchester.
145,363. PNEUMATIC HAMMER. Etablissements H. Dirick et L. Lapaille, Societe en Nom Collectif, of Belgium.

Calumet & Arizona Mining Co. recently purchased the 85 Mine, near Lordsburg, New Mexico. Officers of the new company are Charles Briggs of Calumet, Mich., president; Col. John C. Greenway, general manager and George Jay, purchasing agent. Colonel Greenway and Mr. Jay have their headquarters in Bisbee, Ariz.

Richard P. Tinsley and William Franklin Sands were recently elected as Secretary and Assistant Secretary, respectively, of the American International Corporation, by the Board of Directors. Mr. Pratt, the former Secretary, has entered the law firm of Pratt, McAlpin and Page, and Mr. Ramsburg, former Assistant Secretary is also connected with the law firm.

AIR BRUSHES AID IN COLORING LARGEST MAP

COMPRESSED AIR brushes played an important part in completing the largest bas-relief map of the world ever constructed, and exhibited for the first time at the National Marine Exposition, held in Chicago during October under the auspices of the National Marine League. W. L. Guppy, the designer of the map, and W. James Miskella, wielded the huge brushes.

The coloring of the map brought out in a striking way the flora and fauna of the various countries, climatic conditions, the depths and temperatures of the seven seas, the ocean currents, and the trade routes over which American merchant ships ply their way to foreign ports. It is a good index to the short cuts to available markets, and manufacturers can pick at a glance advantageous routes.

The map which was part of the U. S. Shipping Board's exhibit was constructed under the supervision of the Board at the naval gun factory of the Washington navy yard. It is 40 feet long by fifteen wide and is made of aluminum alloy of so fine a consistency as to take the smallest impressions. Its entire weight including the pedestal equals five tons. The second exhibition of the map will be given in New York, after which it will be seen in New Orleans and then started on a five year tour of the United States.

No doubt great interest will be awakened throughout the country by exhibition of the chart. P. H. W. Ross, President of the National Marine League, declares that this is the beginning of a new era for Americans on the highways of the world, and he holds that no other occupation offers so much to young men in the ways of romance, travel, pay, opportunity and advancement.

NEW NAMES FOR BUREAU OF MINES STATIONS

The following is a list of the mine experiment stations of the Bureau of Mines to which new names have been given for convenience of record and reference:

Location.	Name.	Work.
Bartlesville, Okla.	Petroleum	Oil.
Berkeley, Cal.	Pacific	Chemicals; magnesite; miscellaneous.
Columbus, Ohio.	Ceramic	Ceramics.
Fairbanks, Alaska	Alaska	Development of resources of Alaska.
Minneapolis, Minn.	North Central	Utilization of low-grade iron ores.
Pittsburgh, Pa.	Pittsburgh	Mining; largely coal, electrometallurgy.
Reno, Nevada.	Rare and Precious Metals	Rare and precious metals.
Seattle, Wash.	Northwestern	Ceramics; coal washing; electrometallurgy
Salt Lake City, Utah	Inter-Mountain	Low-grade lead and zinc ores.
Tucson, Ariz.	Southwestern	Low-grade copper ores.
Urbana, Ill.	Central District.	Coal.
Birmingham, Ala.	Southern	Iron and steel; coal; coke; by-products; bi-metallics.
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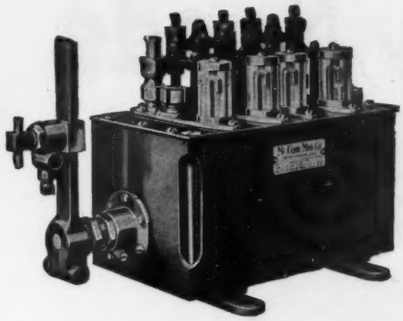

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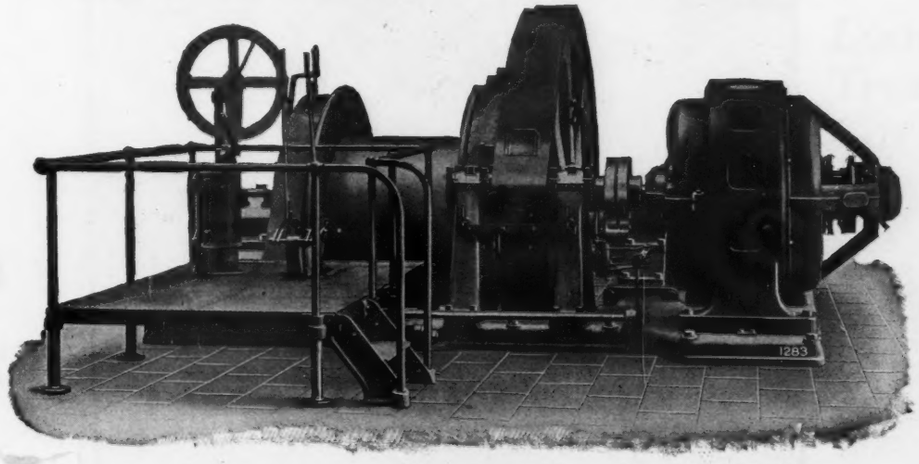

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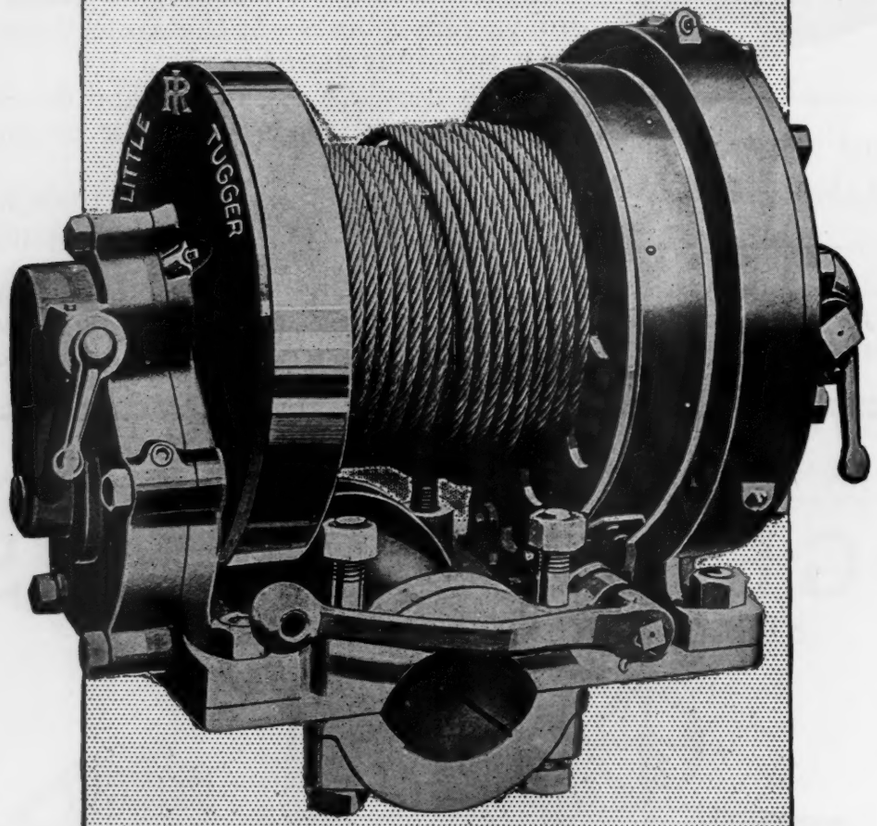

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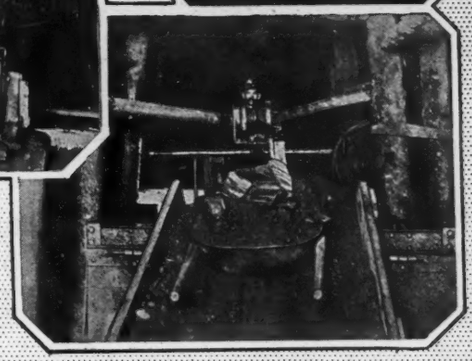

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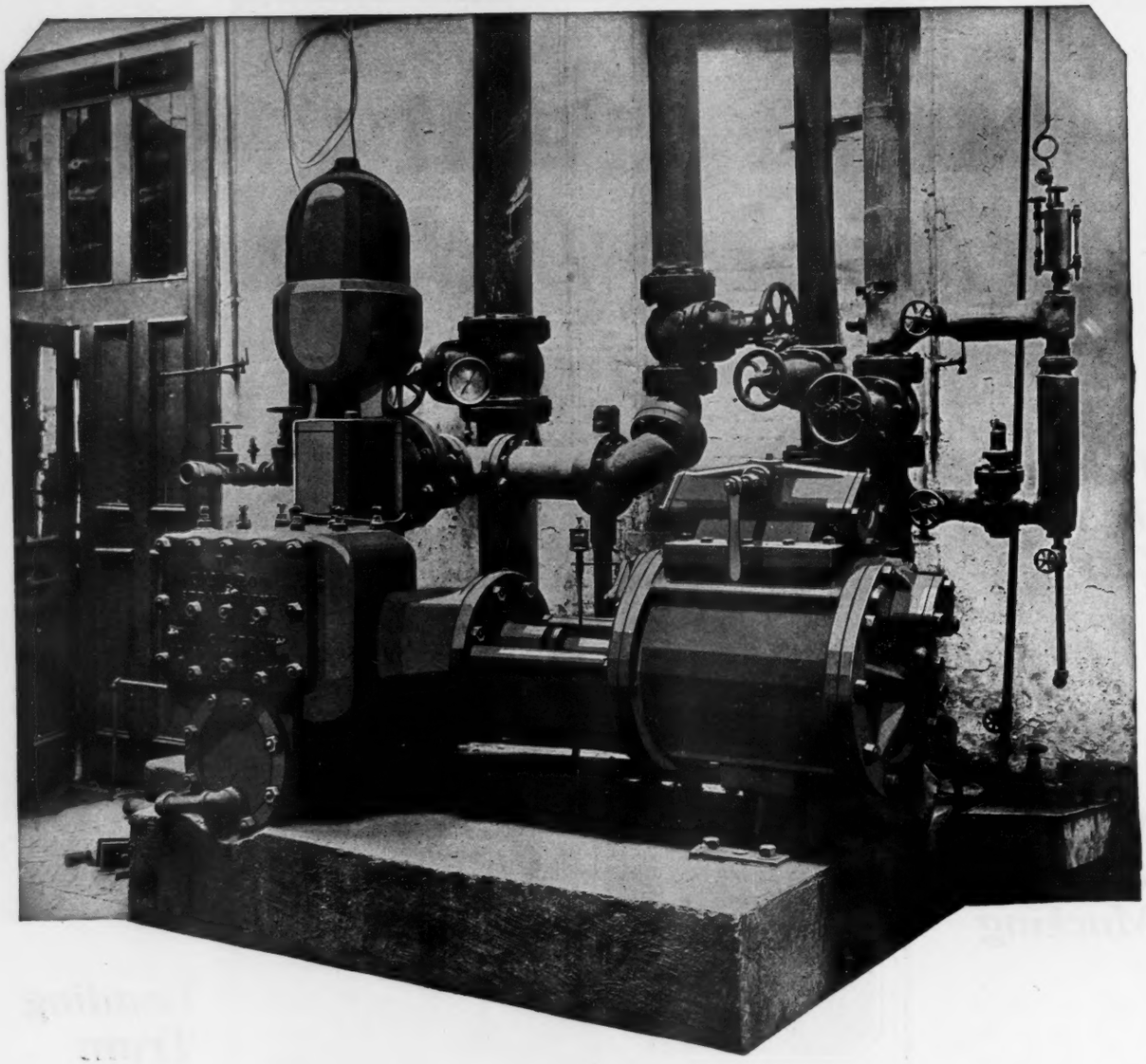

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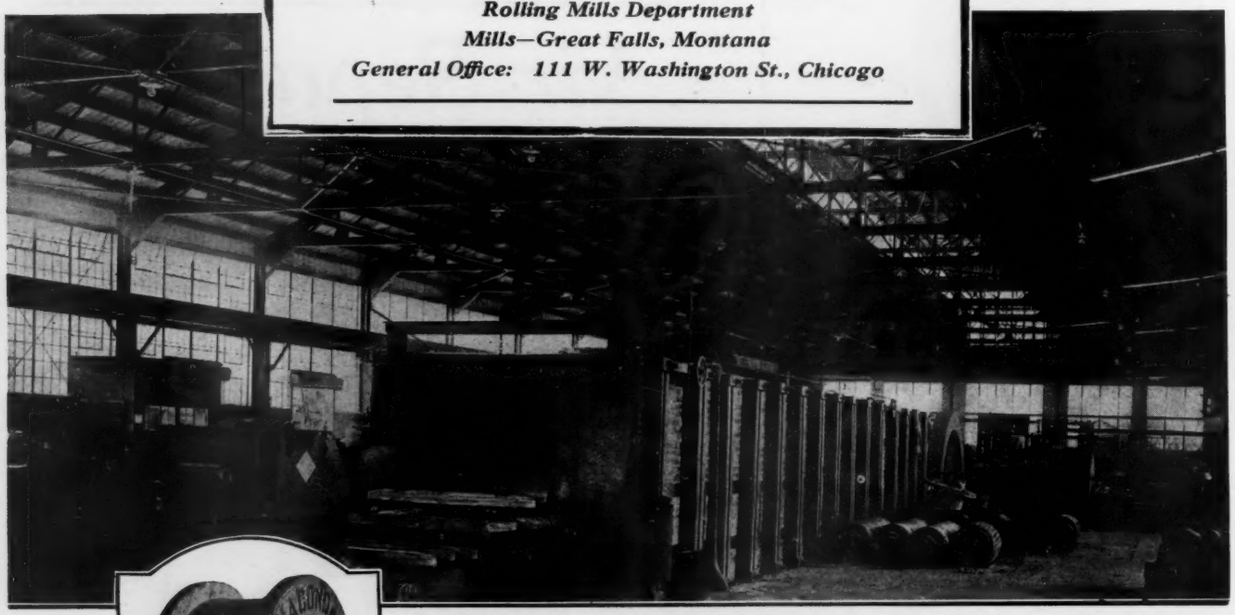

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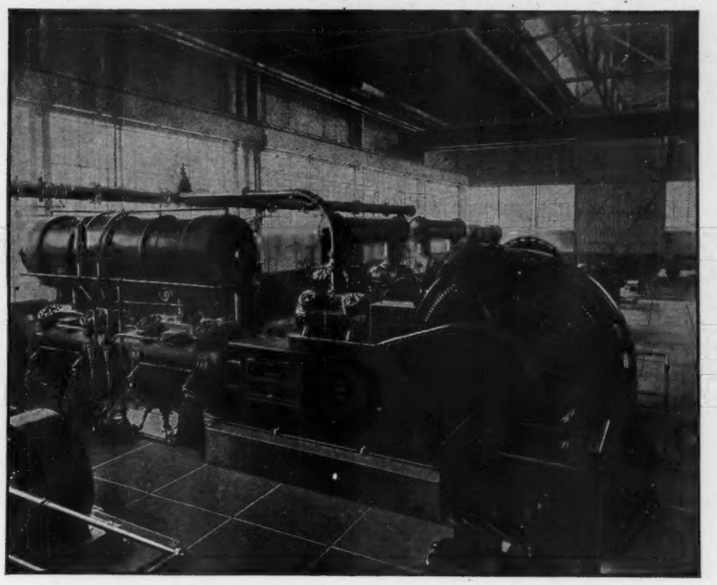

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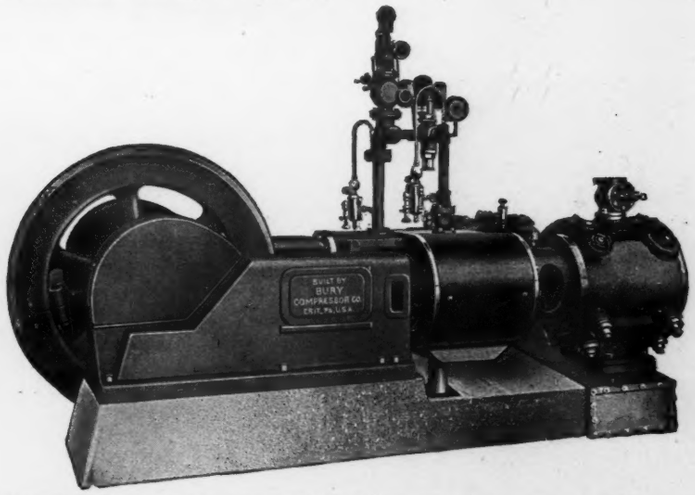

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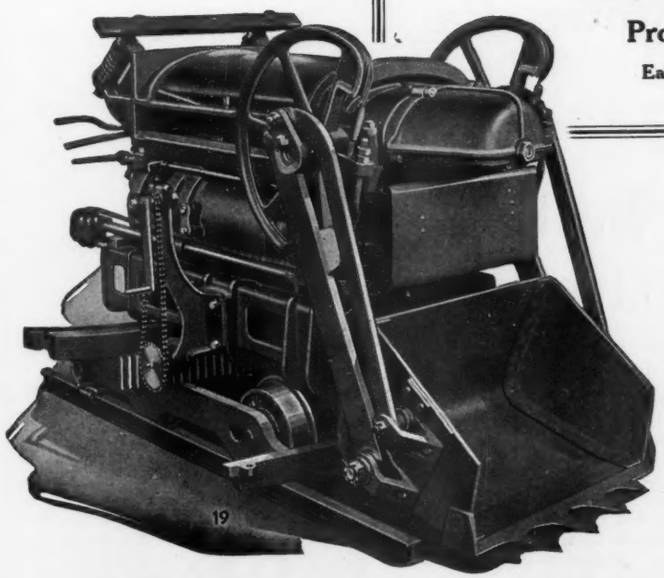

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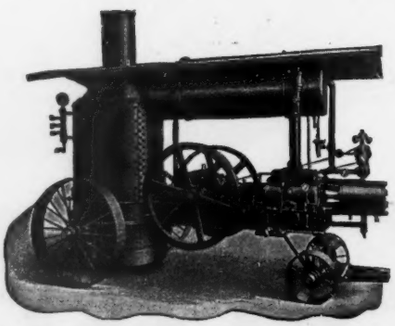

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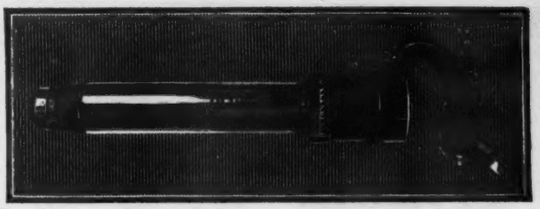

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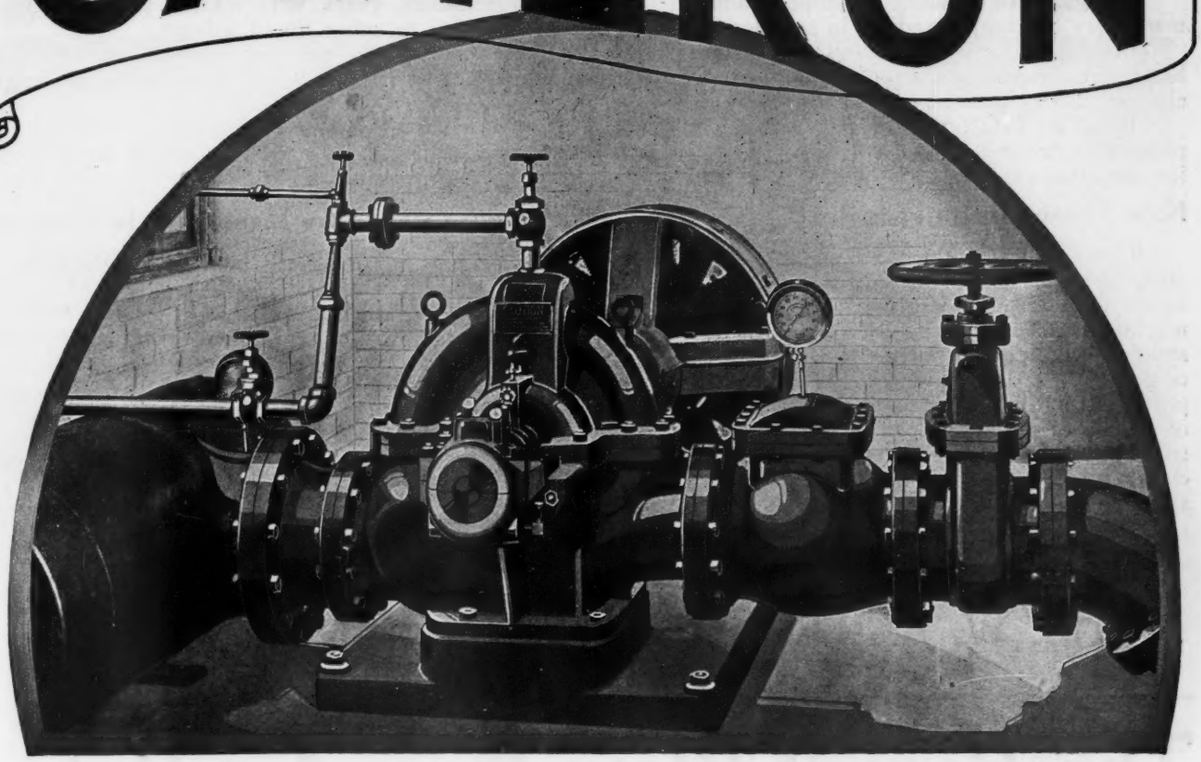

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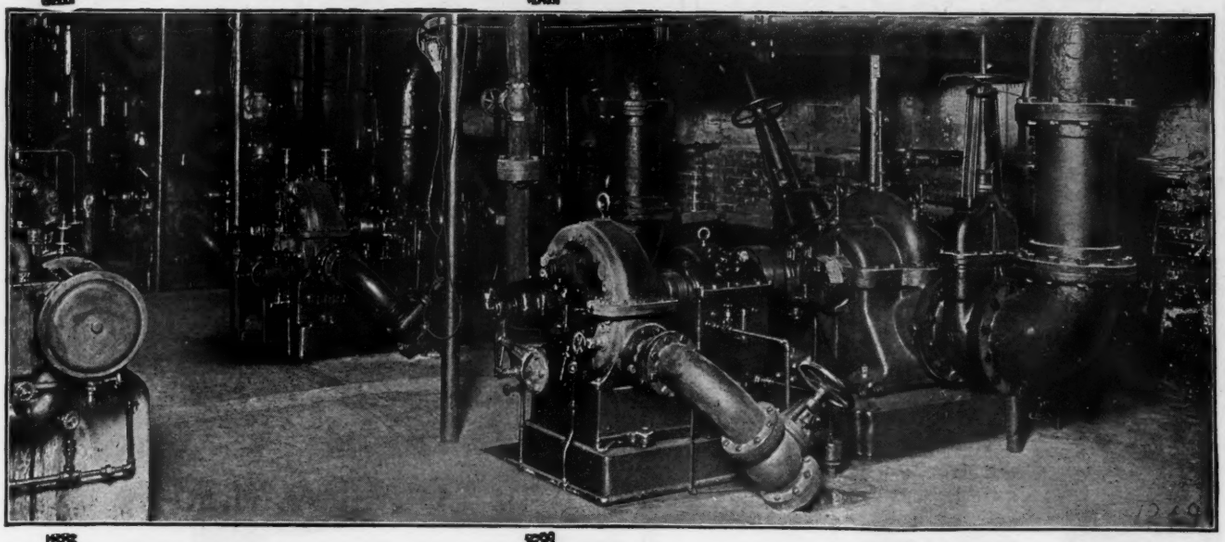

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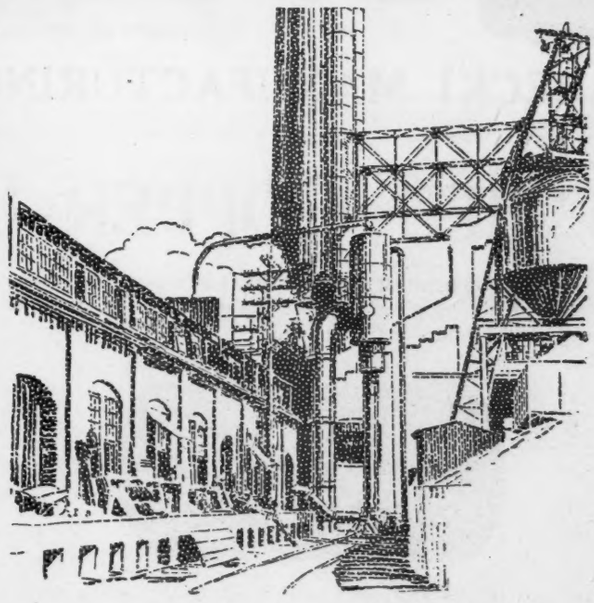

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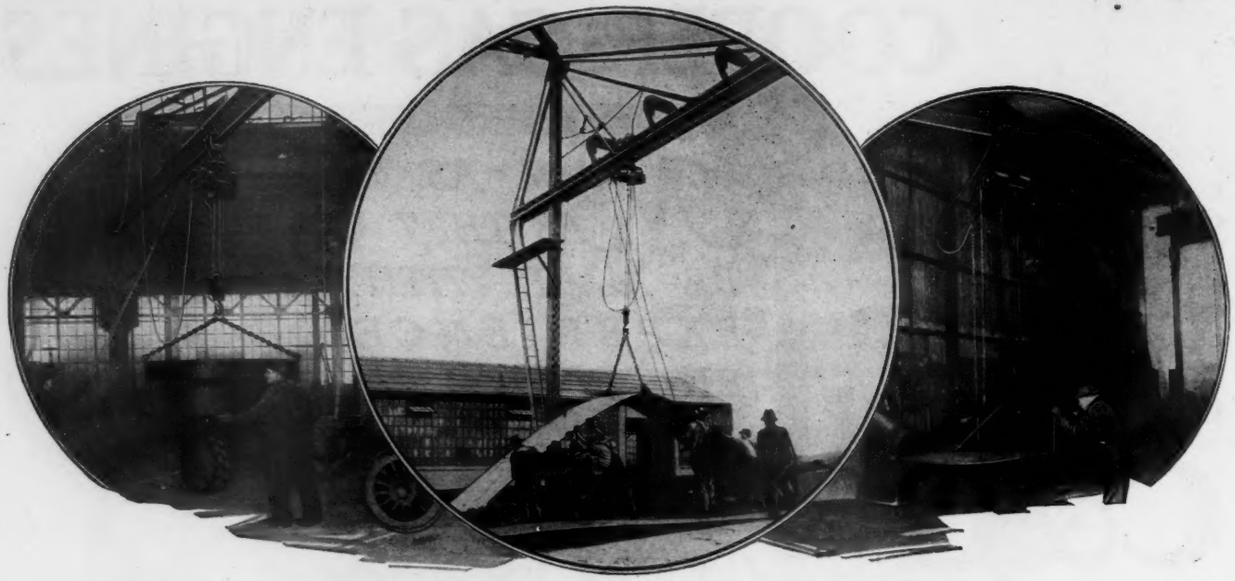

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